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AUTHORITY

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SEG-TR-65-9
SUPPLEMENT 1

COMPARATIVE EVALUATION OF USAF STANDARD A/P22S-2 AND IMPROVED A/P22S-2A HIGH ALTITUDE, FULL PRESSURE FLYING OUTFITS

SUPPLEMENT 1. A/P22S-2A (Mod 1)

KENT W. GILLESPIE

TECHNICAL REPORT SEG-TR-65-9, SUPPLEMENT 1

APRIL 1966

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SYSTEMS ENGINEERING GROUP
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

NOTICES

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SEG-TR-65-9
Supplement 1

FOREWORD

This supplement was prepared by the Crew Support Division, Directorate of Crew and AGE Subsystems Engineering, Systems Engineering Group, Research and Technology Division, Wright-Patterson Air Force Base, Ohio. This supplement documents laboratory evaluations comparing the USAF standard A/P22S-2 High Altitude Full Pressure, Flying Outfit with the A/P22S-2A (Mod 1) outfit. The work is documented under Engineering Service Plan 913A-0000-97090, "ADC Pressure Suit." The A/P22S-2A (Mod 1) outfit was developed and fabricated by the David Clark Company, Inc., Worcester, Massachusetts, under Contract AF 33(657)-10911, Item 2, according to the requirements of the Systems Engineering Group (SEMCE). The A/P22S-2 outfit was a sample of a quantity manufactured by the David Clark Company under Production Contract AF 36(600)-10599.

The evaluation was conducted at Wright-Patterson Air Force Base using the facilities available in the Systems Engineering Group and the 6570th Aerospace Medical Reasearch Laboratories. Mr. Kent W. Gillespie, Systems Engineering Group (SEMCE), was the program monitor.

This supplement was submitted by the author 7 March 1966.

The cooperation and contributions of the following are gratefully acknowledged:

1. 6570th Aerospace Medical Research Laboratories - Mr. Milton Alexander (MRHEA), anthropological data; Mr. John Garnett (MRHEA), hand dexterity data; Mr. Earl Sharp (MRHEM), work-space data; Mr. Kenneth Kennedy (MRHEA), reach data; and Mr. Fritz Klemm (MRBBT), heat exposure data.

2. Systems Engineering Group - Mr. Rey Middleton (SEMCE).

This technical report supplement has been reviewed and is approved.

G. P. Santi

G. P. SANTI
Chief, Crew Support Division
Directorate of Crew and
AGE Subsystems Engineering
Systems Engineering Group

ABSTRACT

In this supplement, the A/P22S-2A (Mod 1) outfit is compared with the A/P22S-2 outfit. The components and factors compared include: weight, leak rate and pressure relief, reach capability, work space, ventilation efficiency, and back pressure. The comments of the persons wearing the outfit were also considered. Results indicate that the A/P22S-2A (Mod 1) shows some improvement over the A/P22S-2; however further improvements are required to make the outfit more operationally acceptable. Specific recommendations are made as to those areas that need improvements.

TABLE OF CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (CONT'D)

ILLUSTRATIONS (CONT'D)

TABLES

SECTION I

DESIGN OF THE A/P22S-2A (MOD 1) FLYING OUTFIT

The contractor (David Clark Company, Inc.) began work on the modified A/P22S-2A outfit (designated A/P22S-2A (Mod 1) in this report) Item 2 of Contract AF 33 (657)-10911, during August 1964. On 6 January 1965, Item 2 was delivered to the Systems Engineering Group (SEG) for evaluation. Item 2 was returned to the Clark Company during February 1965 for modification. It was redelivered to SEG during May 1965. The A/P22S-2A (Mod 1) outfit (Figures 1 and 2) differs from the standard A/P22S-2 outfit as follows: The helmet (Figures 3 through 6) includes a monolithic, conductive coated, heated visor (Figure 7) equal to that used for the protective assembly for the X-15 aircraft. Provision is made for a heated visor on the standard helmet equal to that on the HGU-8/P flying helmet; however the X-15 visor is thicker for added impact resistance and windblast protection. The visor bearings are adjustable to assure visor interchangeability and positioning. The visor and sunshade actuating knobs contain flat plates at the top to serve as guides as an indication to the wearer of direction of movement required. The top back of the shell contains a hole for use of an extremity exhaust valve (Figures 8 and 9) developed under US Navy contract for use on the Mark IV pressure suit. USAF knowledge of the USN development effort and use by TAC of the standard outfit under conditions with the helmet and gloves removed prompted use of this valve. Enough valves to fit the A/P22S-2A (Mod 1) outfit were not immediately available; as a result the U. S. Navy, Aerospace Crew Equipment Laboratory, loaned one valve to the USAF for evaluation.

Modified vent flow control valves (Figure 10) are provided for use in ground level testing. The upper portion of the helmet face barrier is fitted with two snap fasteners for use of modified HGU-4/P sunglasses (Figures 11 and 12) Use of the modified sunglasses requires removal of the nosepieces. These nosepieces are shown in place in the figures. The electrical connection of the heated visor is made by use of a wire at each side of the helmet. A protective cover is provided to contain the wire (Figure 13). The face barrier attachment to the hardshell is similar to the A/P22S-2A by being located closer to the visor opening, which requires the helmet pressure tap to be shortened to make it flush with the inside of the shell. The helmet mounted regulator (Figure 14) is provided with an emergency oxygen makeup valve.

The gloves (Figures 15 through 17) contain white leather (nap side out) palm and fingers. The outseam on the index finger has been moved around the finger toward the back to provide greater sensitivity for sense of feel between thumb and index finger. The insides of the gloves are lined from the wrist ring to the base of the thumb and fingers with a chloroprene-coated ripstop nylon liner for ventilation air distribution. The wrist end of the liner is attached to a vent air distribution ring which is an integral part of the disconnect. The finger end of the liner is attached to a section of nylon mesh which in turn is attached to the glove bladder. The vent air from the coverall is channeled through this liner and exhausts into the glove through the nylon mesh. The wrist ring disconnect contains a bearing.

The lower leg pockets are located at the front of the legs. The coverall outer layer is made of a nylon stretch fabric to permit a closer fit with little or no restriction to mobility. The attachment of the outer layer to the coverall is effected by use of hook-tape, snap fasteners (Figure 18) and slide fasteners. The outer layer partially covers the front holddown webbing to assure exposure of only the outer webbing for manual adjustment. The inside of the coverall is lined with coated ripstop nylon containing 400 ventilation air distribution holes about 0.035-inch diameter (Figure 19). This liner extends into the socks and contains two pieces of nylon mesh at the toes (Figure 20). The pressure relief valve is covered inside the coverall with an antiblock flap held in place with hook tape and snap fasteners (Figure 21). The entry slide fastener and back holddown pulley are covered with a flap closed with snap fasteners

(Figure 22). The helmet neck ring disconnect (Figure 23) is provided with a latch which the wearer can check by touching even with gloves on to assure positive locking. The wrist ring disconnects (Figure 24) contain annular vent air channels to the gloves and a dual latch with an intermediate lock position. A controller without makeup of emergency oxygen (Figures 25 and 26), developed by the USN for use on the improved Mark IV pressure suit, is provided on the right front center of the coverall. The inside of the coverall is provided with a metal basket (Figure 27) and nylon mesh covered triloc to prevent restriction of gas outflow from the coverall through the controller. The outfit at ground level can be pressurized by removing the controller and replacing with an adapter and hose with a standard vent air control valve (Figure 28) on the distal end.

SECTION II

PROCEDURES AND RESULTS

1. WEIGHT

The weights of the component parts of the A/P22S-2A (Mod 1) outfit are presented in Table I.

TABLE I

WEIGHTS OF COMPONENT PARTS OF THE A/P22S-2A (MOD 1) OUTFIT

Component parts	Size	Weight (lbs)
Helmet	n/a	7.19
Coverall	large long	13.25
Gloves (pair)	I	1.25
Assembly total	n/a	21.69

2. LEAK RATE AND PRESSURE RELIEF

Leakage of the outfit was checked using a USAF standard TTU-150/E tester (the loading valve provided with the outfit was used instead of that in the tester). The tester hose adapters could not be used due to interference with the visor heater wire cover. Leak rate was not within the range specified for the standard A/P22S-2 outfit due to use of the modified vent flow control valve used for ground level control of pressure in the outfit. The use of the USN extremity exhaust valves would require use of a testing procedure different from the standard. For this evaluation nonstandard modified vent suit exhaust control valves (Figure 29) were installed on the outfit. Retesting for leakage was accomplished and found to be within the specified range. The pressure relief valve on the coverall performed as required by the specification.[1]

3. PRESSURIZATION GROWTH

Dimensional growth of the A/P22S-2A (Mod 1) and A/P22S-2 outfits on a subject with various levels of internal outfit pressure were measured (Figures 30 through 34). The growths of the components of the two outfits caused by inflation from 0 to 3.5 psi are given in Table II. The inflation increments as the A/P22S-2 outfit is pressurized from the uninflated state to ventilation flow (13 cubic feet per minute) to 1 psi and 3.5 psi are given in Table III. The inflation growth increments as the A/P22S-2A (Mod 1) outfit is pressurized from the uninflated condition through 3.5 psi is given in Table IV.

4. HAND DEXTERITY

The object of the hand dexterity tests was to compare the same subject's performance while dressed in a complete A/P22S-2 outfit with his performance under identical conditions while dressed in a complete A/P22S-2A (Mod 1) outfit. Developed methods utilizing the Purdue Pegboard (Figure 35) were used to measure the manipulative dexterity of the hands in three conditions:

- Condition 1 - Subject suited but barehanded and unpressurized
- Condition 2 - Subject suited, gloved, but unpressurized
- Condition 3 - Subject wearing complete outfit and pressurized to 3.5 psi

Condition 1 constitutes a baseline of maximum hand dexterity for the particular subject against which the decrement in performance during Conditions 2 and 3 are compared.

The procedures as outlined in the Purdue Pegboard Manual were followed with two exceptions. The pegboard was turned 180° during pressurized trials so mobility restrictions in the shoulder of the pressurized suit

[1] Use of a British type valve was considered. After procurement and testing, the valve was unacceptable due to excessive leakage.

TABLE II

DIMENSIONAL GROWTH CAUSED BY INFLATION FROM 0.0 TO 3.5 PSI

	A/P22S-2 (in.)	A/P22S-2A (MOD 1) (in.)
Axillary chest circumference	+ 3.80	+ 6.10
Waist circumference	+ 1.30	+ 4.90
Axillary arm circumference	+ 1.60	+ 1.80
Forearm circumference	+ 1.80	+ 1.80
Thigh circumference	+ 1.40	+ 1.80
Calf circumference	+ 1.30	+ 0.50
Shoulder breath	+ 2.30	+ 5.25
Elbow-to elbow (pressed)	+ 3.40	+ 3.95
Hip breath	+ 0.40	+ 0.95
Posterior body plane - anterior knee area	+ 2.40	+ 6.55
Thigh clearance from floor	+ 0.50	+ 1.10
Sitting height	+ 2.10	- 0.25 (tie-down variability)
Arm reach from board	+ 0.85	+ 1.25 (gloves leave fingers)
Hand length	+ 0.25	+ 0.15
Finger tip to glove tip	+ 0.00	+ 1.60
Hand length from wrist ring	+ 0.65	+ 2.40

would not influence test results, and the normal cup position of "collars" and "washers" was reversed during pressurized trials to eliminate the necessity of crossing hands during performance of the test. These two exceptions helped maintain a more consistent situation throughout the entire testing period. The tests consisted of three trials for each task under each stipulated condition. Scoring was based on the Purdue Pegboard Profile Sheet for Men (Veterans and College Students).

Results of the hand dexterity tests are presented in Tables V and VI.

5. WORK SPACE

The work-space evaluator of the 6570th Aerospace Medical Research Laboratories (AMRL) was used for the study. See Figures 36 through 38.

The total response time to all controls consisted of the time elapsed from the initial presentation of a stimulus light until final activation of the push button had been completed thus extinguishing the stimulus light. The following two components of total response time were measured:

- Reaction time - the time elapsed from the initial presentation of the stimulus light until the subject released the starting switch
- Operation time - the time elapsed from the release of the starting switch until the final activation of the push button

a. Subjects

Two subjects, selected on the basis of their similarity in height, weight, and general body build, served in the work space evaluation. The criterion of near equivalence in stature

TABLE III

NFLATION GROWTH INCREMENTS AS THE A/P22S-2 OUTFIT IS PRESSURIZED

	Uninflated	Ventilation air flow of 13 cfm	Inflated outfit pressure		Total growt
			1 psi	3.5 psi	
Axillary chest circumference	46.00[a]	48.30[a]	49.30[a]	49.80[a]	+3.80[a]
Measured waist circumference	42.80	43.10	43.80	44.10	+1.30
Axillary arm circumference	15.50	16.10	16.80	17.10	+1.60
Forearm circumference	13.30	14.00	15.10	15.10	+1.80
Thigh circumference	20.50	22.30	21.70	21.90	+1.40
Calf circumference	17.70	17.80	18.90	19.00	+1.30
Shoulder breadth	21.40	22.00	22.50	23.70	+2.30
Elbow-to-elbow breadth (pressed)	21.95	22.20	24.25	25.35	+3.40
Hip breadth	15.85	15.95	16.40	16.25	+0.40
Posterior body plane - anterior knee area	28.55	29.95	31.40	30.95	+2.40
Thigh clearance from floor	25.20	25.80	25.95	25.70	+0.50
Sitting height	36.15	36.90	37.15	38.25	+2.10
Arm reach from board	36.95	37.35	36.95	37.80	+0.85
Hand length	7.70	7.95	7.90	7.95	+0.25
Finger tip to glove tip	0.00	0.00	0.00	0.00	0.00
Hand length from wrist ring	11.15	11.45	11.55	11.80	+0.65

[a] All increments in inches

was dictated by the requirement that each subject was able to wear both suits.

b. Procedure

For task familiarization, both subjects performed practice sessions that were identical to the data sessions, except for the absence of a pressure suit. For the data sessions, the subjects wore the full pressure outfits.

Table VII shows the counterbalancing sequence used in the data sessions.

The first and last pressurization condition (unpressurized) were run with the suit inflat and ventilated and with the helmet visc closed. The other two pressurization cond tions were accomplished with the suit pres surized to 3.5 pounds per square inch. Or unpressurized and one pressurized run wer accomplished within one session, and eac subject performed two sessions, one sessic on each of two different days. The entire prc cedure was then repeated, using the sar subject in the second suit. All push buttc

TABLE IV

INFLATION GROWTH INCREMENTS AS THE A/P22S-2A (MOD 1) OUTFIT IS PRESSURIZED

	Uninflated	Ventilation air flow of 13 cfm	Inflated outfit pressure		Total growth
			1 psi	3.5 psi	
Axillary chest circumference	43.30[a]	47.50[a]	47.70[a]	49.40[a]	+6.10[a]
Measured waist circumference	41.70	45.00	45.30	46.60	+4.90
Axillary arm circumference	15.90	16.50	17.50	17.70	+1.80
Forearm circumference	14.10	14.30	15.10	15.90	+1.80
Thigh circumference	20.10	20.70	21.20	21.90	+1.80
Calf circumference	17.50	17.50	17.70	18.00	+0.50
Shoulder breadth	21.95	23.30	25.00	27.20	+5.25
Elbow-to-elbow breadth (pressed)	21.95	23.50	24.50	25.90	+3.95
Hip breadth	15.65	16.20	16.20	16.60	+ .95
Posterior body plane - anterior knee area	25.80	27.15	29.10	32.35	+6.55
Thigh clearance from floor	25.75	25.90	25.95	26.85	+1.10
Sitting height	37.40	35.80	36.50	37.15	-0.25
Arm reach from board	36.30	37.85	38.80	37.55	+1.25
Hand length	7.95	8.00	8.00	8.10	+ .15
Finger tip to glove tip	0.00	0.00	0.45	1.60	+1.60
Hand length from wrist ring	10.35	10.55	10.85	12.75	+2.40

[a] All increments in inches

controls located to the right of the subject's mid-sagittal plane were operated with the right hand (the starting switch located just above the knee on the right thigh) and all push button controls located to the left of the subject's mid-sagittal plane were operated with the left hand (the starting switch located just above the knee on the left thigh). The subject was required to respond to each of the push buttons to the right of the mid-sagittal plane in a predetermined random sequence until each control was operated five times (replicates) with the right hand. The starting switch was then shifted to the left thigh and the same procedure followed for the left-hand operation of the buttons located to the left of the subject's mid-sagittal plane. The procedure was then repeated in the pressurized condition, reversing the hand conditions, to complete one session. On a different day, usually the day following the first session, the second session was accomplished, reversing the order of pressurization to complete one suit/subject combination (4

TABLE V

SUBJECT'S PERFORMANCE SCORES FOR HAND DEXTERITY WHILE WEARING THE A/P22S-2 AND A/P22S-2A (MOD 1) OUTFITS

	A/P22S-2 outfit			A/P22S-2A (Mod 1) outfit		
	Barehanded	Gloved no pressure	Gloves 3.5 psi	Barehanded	Gloved no pressure	Gloves 3.5 psi
Right hand	52 (55%)	39	19	46 (21%)	34	13
Left hand	55 (87%)	35	14	56 (90%)	30	9
Both hands	46 (92%)	28	11	47 (95%)	20	3
Assembly	136 (84%)	57	21	110 (33%)	52	13

Percentages in parentheses indicate comparative rating as listed in the Purdue Pegboard Manual.

TABLE VI

SUBJECT'S PERCENTAGE OF PERFORMANCE RETENTION DURING EACH TASK WHILE WEARING THE A/P22S-2 AND A/P22S-2A (MOD 1) OUTFITS AND GLOVES

	A/P22S-2 outfit			A/P22S-2A (Mod 1) outfit		
	Barehanded	Gloved no pressure	Gloves 3.5 psi	Barehanded	Gloved no pressure	Gloves 3.5 psi
Right hand	100	75.0	36.5	100	73.9	28.3
Left hand	100	63.6	25.5	100	55.6	16.0
Both hands	100	60.9	23.9	100	42.6	6.4
Assembly	100	41.9	15.4	100	47.3	11.8

TABLE VII

COUNTERBALANCING SEQUENCE FOR SUITED CONDITIONS

Session	1				2			
Pressurization: unpressurized (U) or pressurized (P)	U		P		P		U	
Hand condition: left (L) or right (R)	R	L	L	R	R	L	L	R

locations, 5 replicates, 2 hands, 2 pressure conditions, and 2 sessions) consisting of 160 separate operations.

c. Results

The results of the comparative testing of the A/P22S-2 and the A/P22S-2A (Mod 1) outfits on the work space evaluator are shown in Table VIII and Figure 39.

6. REACH CAPABILITY

Reach capability was determined on one subject when wearing the A/P22S-2 full-pressure flying outfit and when wearing the A/P22S-2A (Mod 1) outfit. See Figures 40 through 42.

Reach capability can be measured in at least two basically different ways. One way is to measure the distance that a person can reach from a known point. This may be referred to as linear reach capability and is directly related to the length of the arm. The second way of measuring reach is to describe the maximum excursion of the hand in terms of its angle from a defined point in space or on the body of the subject. This may be referred to as angular reach capability and is related principally to the inherent mobility of the joints of the shoulder and elbow and to the impedance a restrictive garment places on the mobility of these joints. Determination of reach capability is important in evaluating and comparing mobility in full pressure outfits and in the layout of work spaces.

The method chosen for comparing reach in the two suits was a relatively simple combination of these methods. Reach capability in the three cardinal planes (parasagittal, frontal, and horizontal) were ascertained through the use of a grasping-reach measuring device (reference Item 3 of the Bibliography).

Scale drawings of the cardinal planes through the reach capability envelopes for the unpressurized (vented) and for 3.5 psig conditions are shown in Figure 43 through 48. The comparison of the two outfits was facilitated by superimposing reach contours depicting reach capability at the two stated conditions.

7. VENTILATION EFFICIENCY

A physical test was arranged to study the effect of the vent air exhaust valves. In this experiment the ventilating air flow resistance of the outfit (determined at the entrance of the ventilating air in the suit) and the pressure in the suit were measured at different air flows and valve positions. Results are shown in Figures 49 and 50. This test was conducted with a subject wearing the outfit.

For the purpose of comparison of the efficiency of the A/P22S-2A (Mod 1) ventilating system with that of the standard A/P22S-2 outfit, six heat exposure experiments with the A/P22S-2A (Mod 1) and three experiments with the standard A/P22S-2 assembly were conducted (Figures 51 and 52). In all tests, the same environmental and ventilating conditions were maintained. An air-wall temperature of 49°C (120°F) and a ventilating air flow of 11 cfm of 21°C (70°F) (dry) were considered sufficiently stressful to produce differences in physiological response of the sitting resting subject due to the ventilating systems. The physiological responses under the test conditions are shown in Table IX and Figure 53 through 55 and are expressed in the following:

a. Body heat storage (Kcal/m^2) Figure 53

b. The mean weighted skin temperature (based on 17 measurements) and rectal temperature profiles as shown in Figure 54 and 55

c. Index of physiological strain which is expressed in

$$I_s = \frac{HR}{100} + \Delta t_r + r_s$$

whereby HR = heart rate (beats/min) at end of 1 hour exposure

Δt_r = rise in rectal temperature in °C/hr

r_s = sweat production (nude weight loss in kilograms/hr)

This index will yield values close to 1.0 at the upper limit of comfort.

TABLE VIII. MEAN COMPONENT TIME SCORES FOR EACH LOCATION

TIME SCORES			Left hand location								Right hand location							
			1		2		3		4		1		2		3		4	
			$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
UNINFLATED	A/P 22S-2 •	Reaction time	.41	.05	.42	.06	.40	.05	.41	.05	.40	.03	.38	.03	.41	.04	.42	.05
		Operation time	.58	.24	.71	.26	.47	.24	.54	.31	.55	.14	.71	.42	.36	.12	.53	.24
		Total time	.99	.23	1.13	.25	.86	.25	.96	.33	.95	.16	1.08	.43	.77	.14	.95	.24
	A/P 22S-2A (Mod 1)	Reaction time	.40	.06	.40	.07	.41	.06	.40	.05	.39	.04	.44	.08	.40	.05	.42	.07
		Operation time	.56	.26	.66	.39	.46	.21	.56	.34	.62	.37	.41	.13	.35	.15	.49	.23
		Total time	.96	.26	1.05	.40	.87	.20	.96	.34	1.01	.36	.85	.17	.75	.17	.92	.24
INFLATED	A/P 22S-2	Reaction time	.46	.12	.44	.10	.40	.08	.51	.16	.41	.06	.42	.10	.39	.05	.41	.05
		Operation time	.88	.49	.85	.44	.65	.38	1.17	.48	.80	.46	.82	.36	.46	.19	.96	.25
		Total time	1.34	.48	1.29	.46	1.05	.38	1.69	.51	1.21	.47	1.25	.37	.85	.20	1.37	.27
	A/P22S-2A (Mod 1)	Reaction time	.42	.06	.40	.07	.40	.07	.43	.09	.43	.15	.42	.10	.48	.36	.46	.15
		Operation time	.90	.35	.67	.22	.64	.41	.95	.53	.75	.48	.75	.42	.65	.29	.85	.33
		Total time	1.32	.35	1.07	.24	1.05	.44	1.38	.54	1.18	.49	1.17	.41	1.13	.49	1.31	.40
Percent increase in activation time from uninflated to inflated condition	A/P22S-2	Operation time	53		19		39		115		45		17		26		81	
		Total time	36		14		21		76		28		15		10		44	
	A/P22S-2A (Mod 1)	Operation time	60		2		40		69		20		81		88		72	
		Total time	38		2		21		43		16		38		51		43	

See Table V of SEG-TR-65-9 for description of locations

$\bar{X}$ = arithmetic mean (in seconds)
SD = standard deviation (in seconds)

TABLE IX

VENTILATION EFFICIENCY PROGRAM AND RESULTS

	A/P22S-2A (Mod 1)			A/P22S-2	
	With helmet and gloves (0_2 breathing)		Without helmet and gloves (After 60 minutes, all valves open)		
	Ventilating valve at helmet open; other 4 valves closed	All ventilating valves open except valve at helmet		With helmet and gloves (0_2 breathing)	Without helmet and gloves
Conditions:					
Test series	I	II	III	IV	V
No. of tests	2	2	2	1	2
Test duration(Minutes)	90	60	90	60	60
Ambient temperatures (°C)	49(120°F)	49	49	49	49
Ventilating air flow (cfm)	11	11	11	11	11
Ventilating air temp (°C)	21(70°F)	21	21	21	21
Ventilating air humidity	dry	dry	dry	dry	dry
Results:					
Index of strain (I_s)	1.20	1.23	1.25	1.10	1.13
Body heat storage (Q_s Kcal/m^2 hr)	27.6	29.5	33	24.6	33.1
Sweat produced (g/hr)	285	220	340	328	268
Sweat evaporated (g/hr)	202	153	204	200	169
Evaporation ratio (E/S)	70	69.5	60	61	63
Rectal temperature rise (°C/hr)	0.08	0.08	0.06	-0.05	0.08
Average skin temperature rise (°C/hr)	2.7	2.3	3.2	2.7	3.2
Average body temperature rise (°C/hr)	1.0	1.0	1.1	0.8	1.1

d. The evaporation ratio

$$(^E/S) = \frac{\text{sweat evaporated}}{\text{sweat produced}} \times 100\ (\%)$$

indicating how much of the sweat produced is evaporated. Thus an indication of the efficiency of the ventilating system is presented.

The body temperatures were continuously recorded at intervals of 90 seconds. The heart rate was counted in 5 to 10 minute intervals.[2] Sweat produced and evaporated was obtained by weighing before and after the tests. Each test was repeated once with another subject except for the Test IV in Table IX. Its results correspond with previous reported data.

The test program was started with the Test Series 1 of Table IX. The subject wore the modified outfit with helmet and gloves. The escape valve for the ventilating air at the helmet was open to prevent ballooning of the coverall. After 60 minutes exposure and stabilization of the body temperature, all valves were opened causing a slight drop in skin temperature and body heat storage. These decreases led to the assumption that closing the helmet valve and opening of the four remaining valves may provide better cooling of the subject. Thus the Test Series II (all valves open, except helmet and valve) was initiated. However, the subject's physiological response was essentially the same as in Test Series I.

8. COMMENTS OF SUBJECTS

Comments of those persons who wore the A/P22S-2A (Mod 1) outfit, concerning this outfit were:

a. The exhalation valve does not always stay in place during donning and/or doffing of the helmet.

b. The coverall is extremely difficult to don. (This is due to the indicated size being larger than the actual size.) This comment was received from persons of the large long size. Medium long size persons did not have as much difficulty.

c. The coverall liner tears easily and is not as much of an aid to donning as the standard A/P22S-2 outfit nylon liner.

d. The location of the air vent exhaust valves on the legs causes pressure points on the shin bones.

e. Adjustment of the helmet exhaust valve results in considerable fluctuation of pressure in the outfit.

f. Certain combinations of vent air flow and pressure in the outfit create a negative pressure area on the skin near the controller mounting. It feels as if a vacuum cup is being applied to the skins surface.

g. The mounting screw of the sunglasses adapter and sharp edges of the washer at the nosepiece contact the skin and cause severe irritation (this screw was reversed to place the screw head toward the skin and the sharp edge was rounded).

h. It felt more comfortable with the gloves and helmet removed during the thermal tests.

i. The gloves are more difficult to don and doff than the standard A/P22S-2 gloves.

j. The entry slide fastener cover is impossible to snap closed at the back without assistance and does not stay closed. In addition, the cover catches in the slider unless it is held aside.

k. The end of the entry slide fastener causes a pressure point at the mid-back.

l. Reflection of the frame image of the sunglasses from the visor inner surface was pronounced and objectionable.

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[2] Since there was almost no change in heart rate, it is not graphically presented.

SECTION III

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

Performance retention of manipulative hand dexterity was greater for each task when the subject wore the A/P22S-2 pressure suit.

When the performance of the two outfits is compared, no consistent overall difference is apparent. An examination of Table VIII reveals that the reaction time component was virtually constant over all conditions and contributed very little to overall performance variability. The other component of total activation time (operation time) did vary widely as a function of pressure condition and push button location. The percentage increment in total activation time in shifting from the unpressurized to the pressurized condition was particularly severe at Location 4. Also, subjects wearing the A/P22S-2A (Mod 1) outfit suffered a greater penalty at Positions 2 and 3 due to inflation when operating with the right hand than when operating either with the left hand or while wearing the A/P22S-2 outfit.

The small increase of suit resistance when the sleeve valves are closed demonstrates poor air supply to the arms and hands.

Even under conditions of slightly higher heat stress (experiments without helmet and gloves), higher body heat storage and higher skin temperatures were observed, and the subjects reported that the experiments were more comfortable without helmet and gloves.

During donning of the helmet, the exhalation valve located in the rubber face seal popped out of the grooves of the rubber ring in which it was located. Dislocation of the valve occurs by stretching the face barrier during donning.

The results show no marked difference between the efficiencies of the two ventilating systems.

The extremity valves provided with the outfit are not leak-tight as required by functional requirements.

The extremity valves do not provide the anticipated improvement in efficiency of the outfit ventilation system. This is, in part, due to the coverall vent air distribution not being effective to the degree required.

There was slightly increased heat stress in the tests conducted without helmet and gloves. The test subjects, however, felt more comfortable without these items than when wearing them.

The indicated coverall size (large long) is not in accordance with the USAF eight size, height-weight data as required. This is attributed to improper allowance for the coverall vent air distribution layers.

2. RECOMMENDATIONS

a. The extremity exhaust valves are not recommended for use with an outfit similar to that used in this evaluation. In addition, reliability of aneroid controlled oxygen systems is not such that inflation should be dependent upon more than one (the modified outfit with exhaust valves uses six separate aneroids).

b. An outfit pressure controller similar to that discussed herein except with a push-to-test feature should be investigated as a feasible improvement.

c. The exhalation valve mounting grommet should not be used due to failure in retention of the valve. The standard grommet is considered more reliable.

d. Strict adherence to USAF sizing requirements should be required on future coveralls of this type.

e. The inner liner should be made of a more durable material to prevent tearing.

f. The method for mounting the sunglasses should be among those being considered by Aerospace Medical Division for a solution to the problem of use of eyeglasses with pressure suit helmets.

g. The entry slide fastener cover provided on the outfit is not recommended as a satisfactory solution to the problem.

h. A lock for the entry slide fastener equal to that used on the standard A/P22S-2 outfit should have been included on the outfit.

i. The vent air liner in the gloves and socks is not considered practical at this time. Extension of the standard outfit vent air channels at the wrists and ankles to alleviate sweating of the hands and feet is recommended.

j. The stretchable outer cover is not recommended for further consideration due to slight mobility impairment. Material equal to that provided as a liner on the standard outfit is recommended as an outer layer.

APPENDIX

ILLUSTRATIONS

Figure 1. Front View of the A/P22S-2A (Mod 1) Outfit

Figure 2. Back View of A/P22S-2A (Mod 1) Outfit

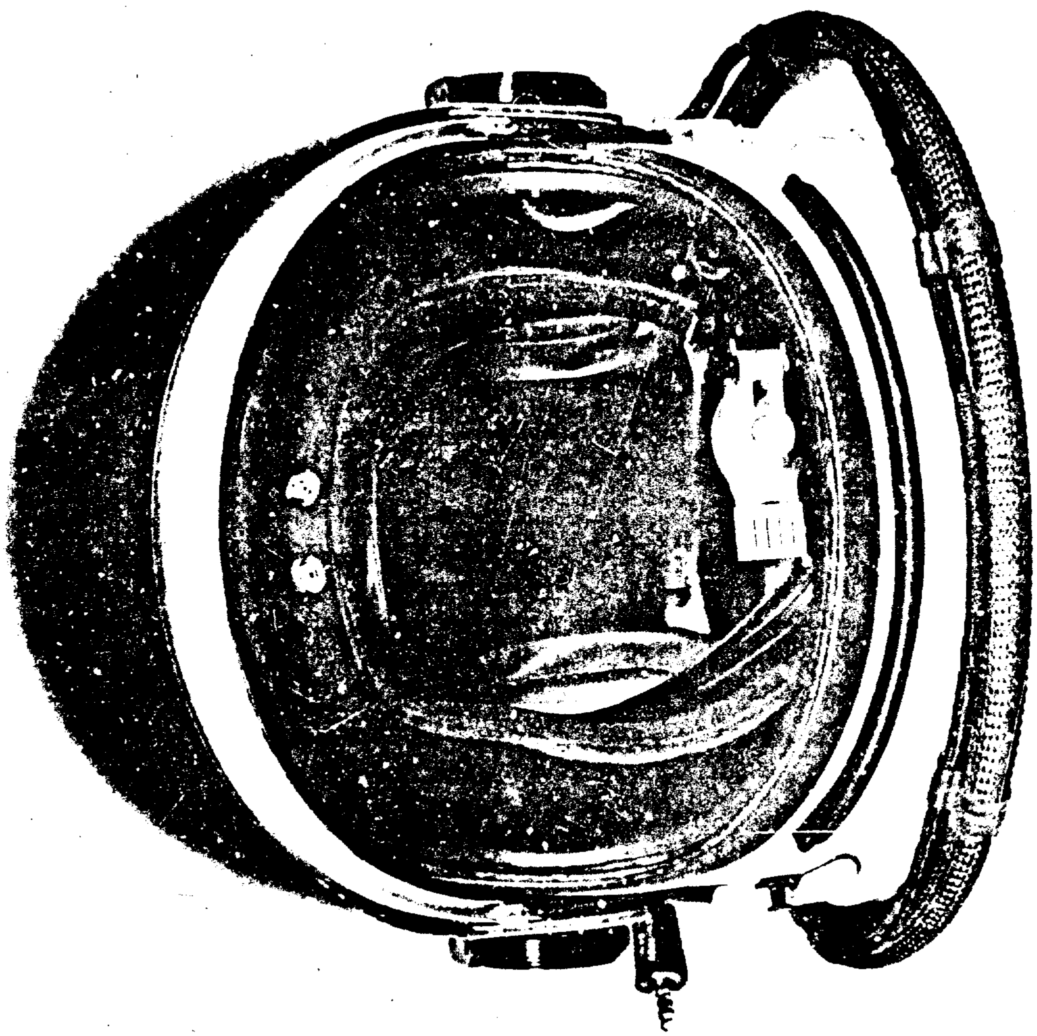


Figure 3. Front View of the A/P22S-2A (Mod 1) Helmet

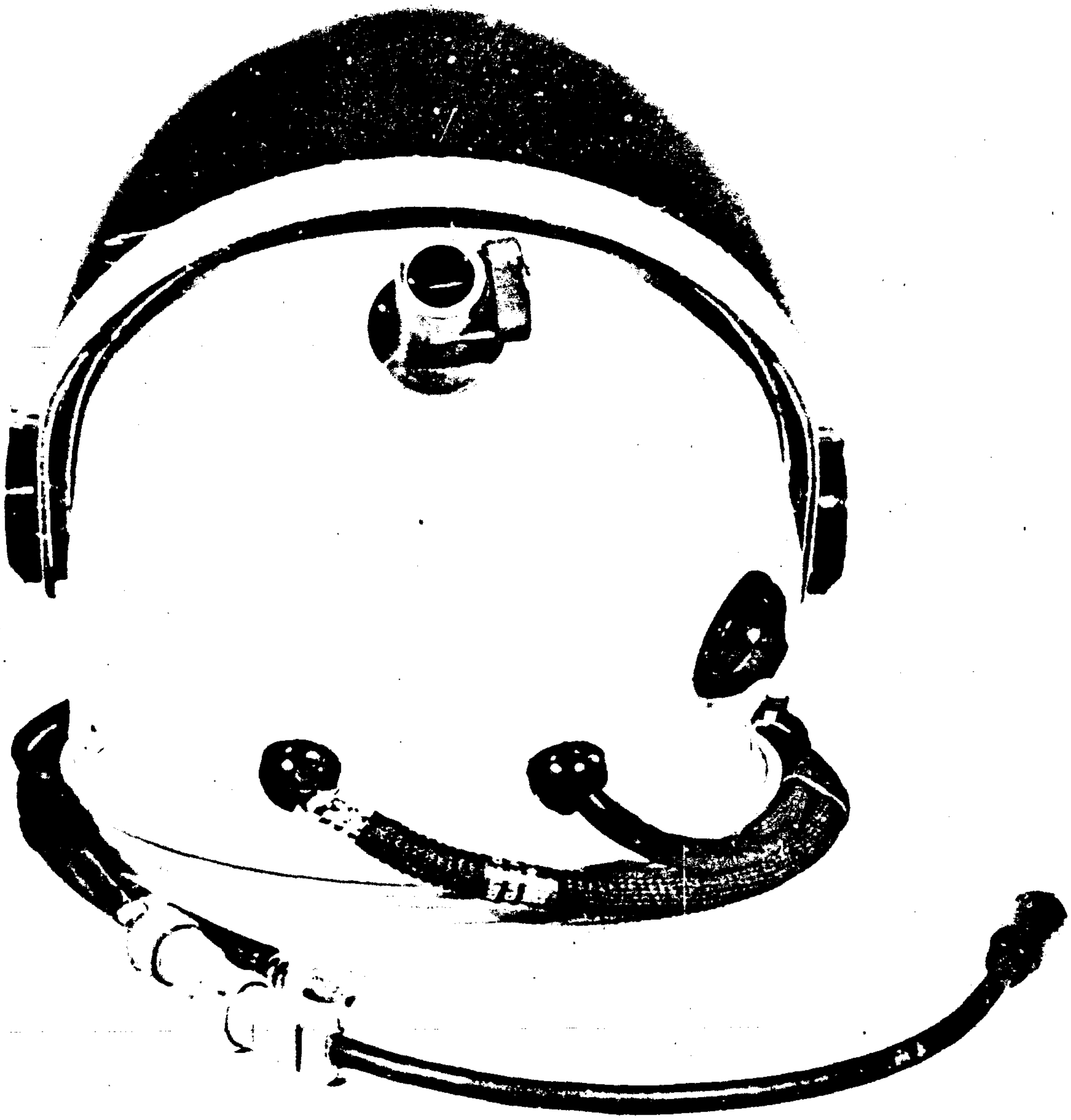


Figure 4. Back View of the A/P22S-2A (Mod 1) Helmet

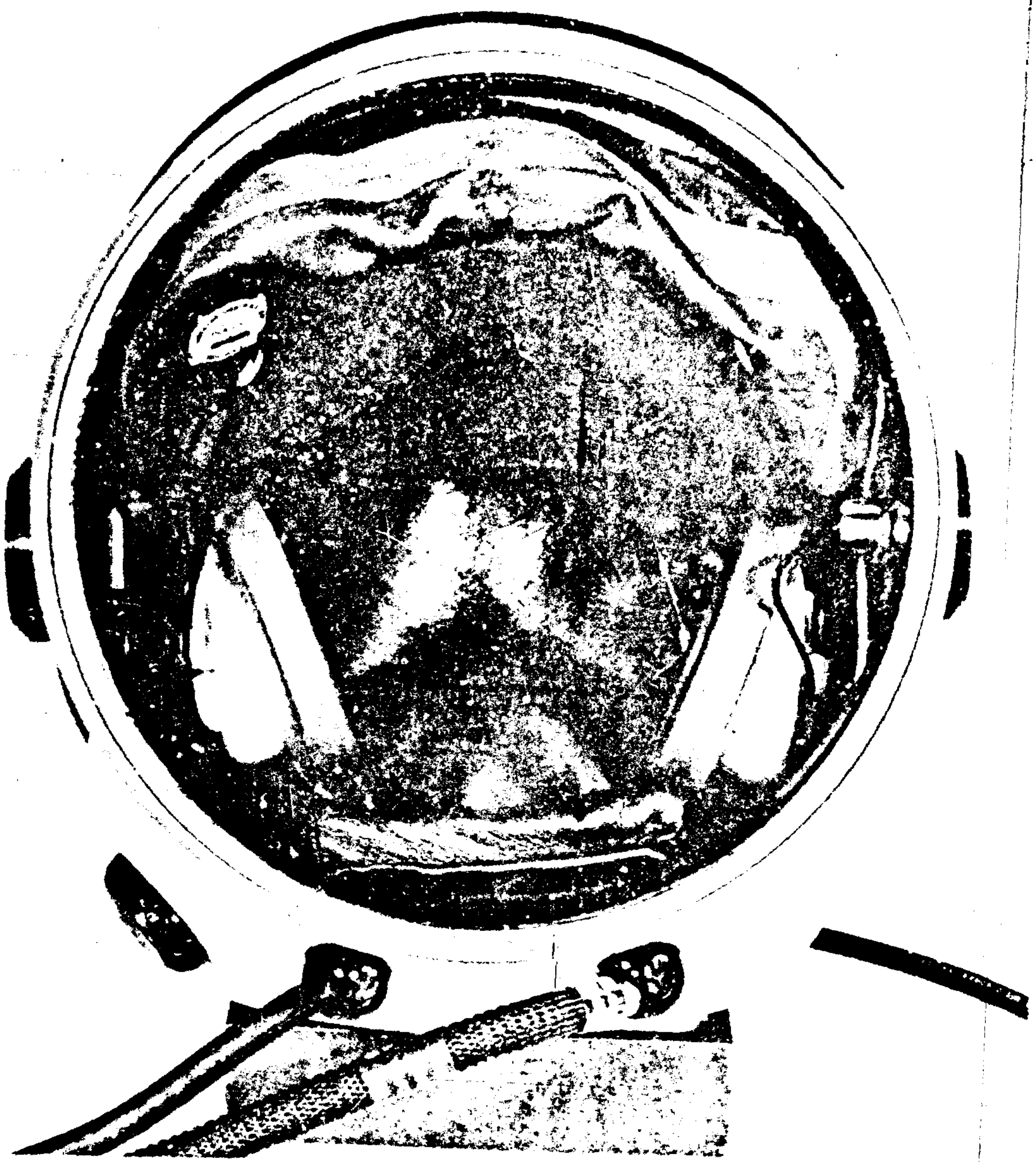


Figure 5. Bottom View of the A/P22S-2A (Mod 1) Helmet

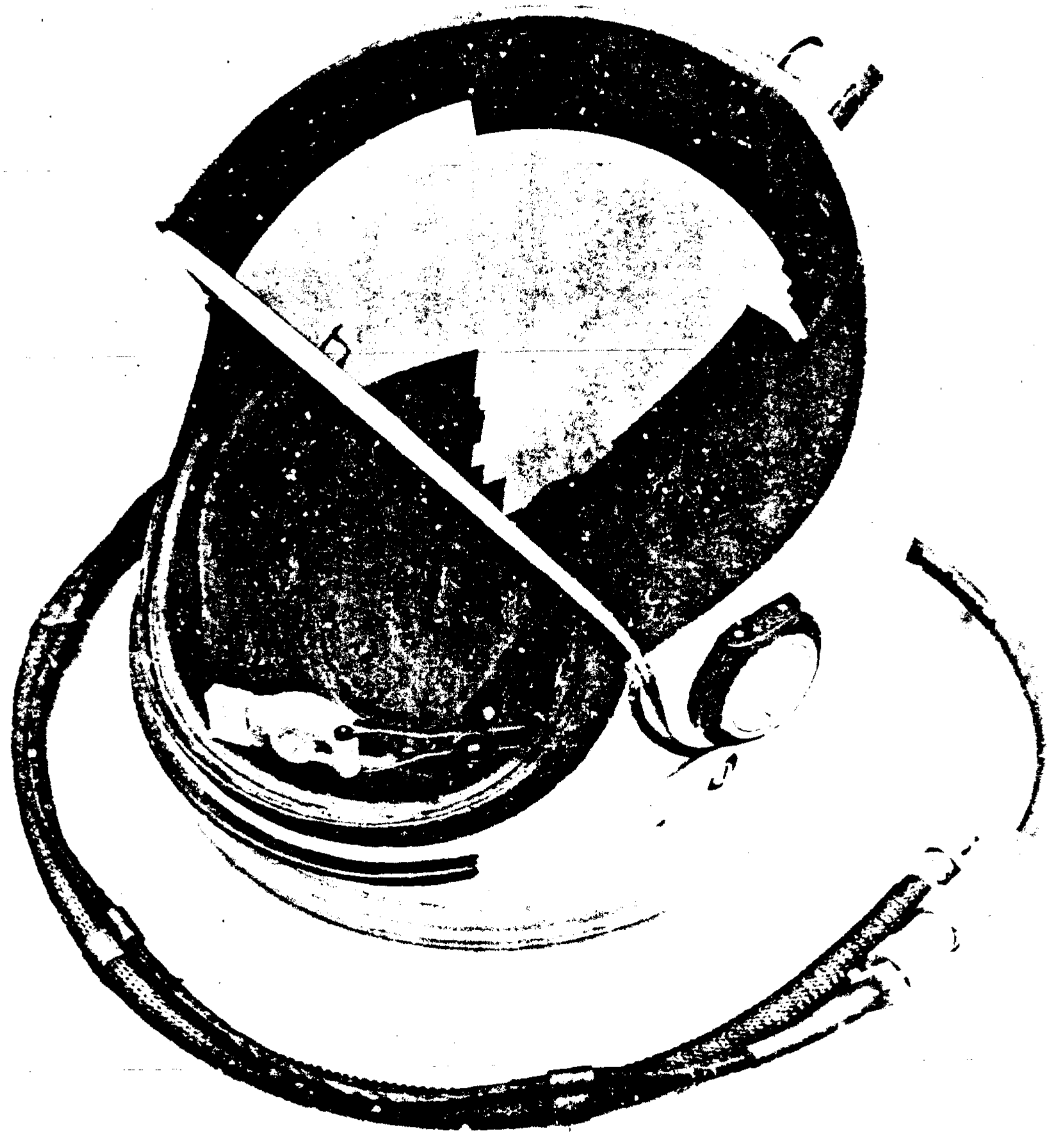


Figure 6. Side View of the A/P22S-2A (Mod 1) Helmet

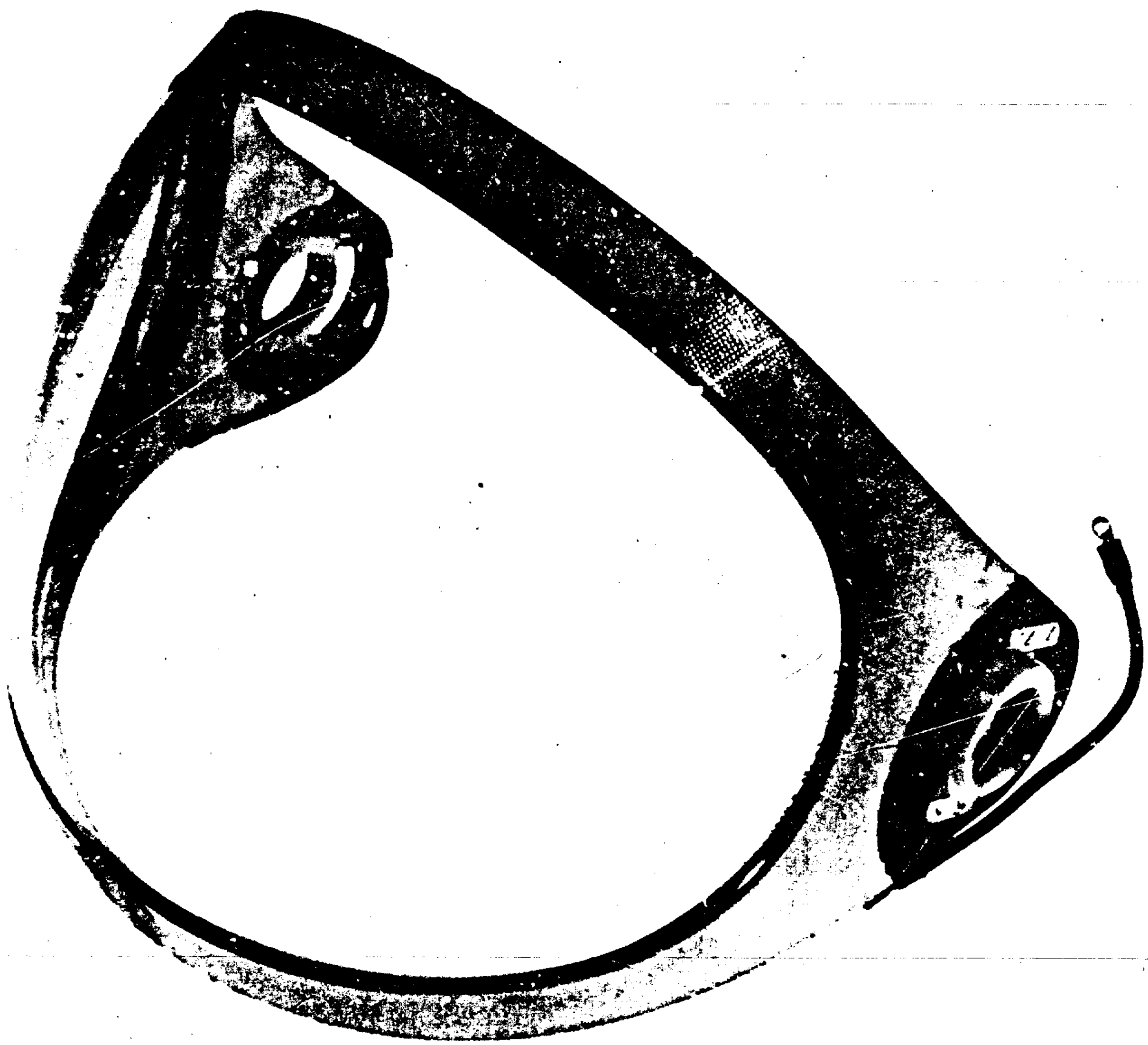


Figure 7. Helmet Visor Removed From Helmet Showing Adjustable Bearings

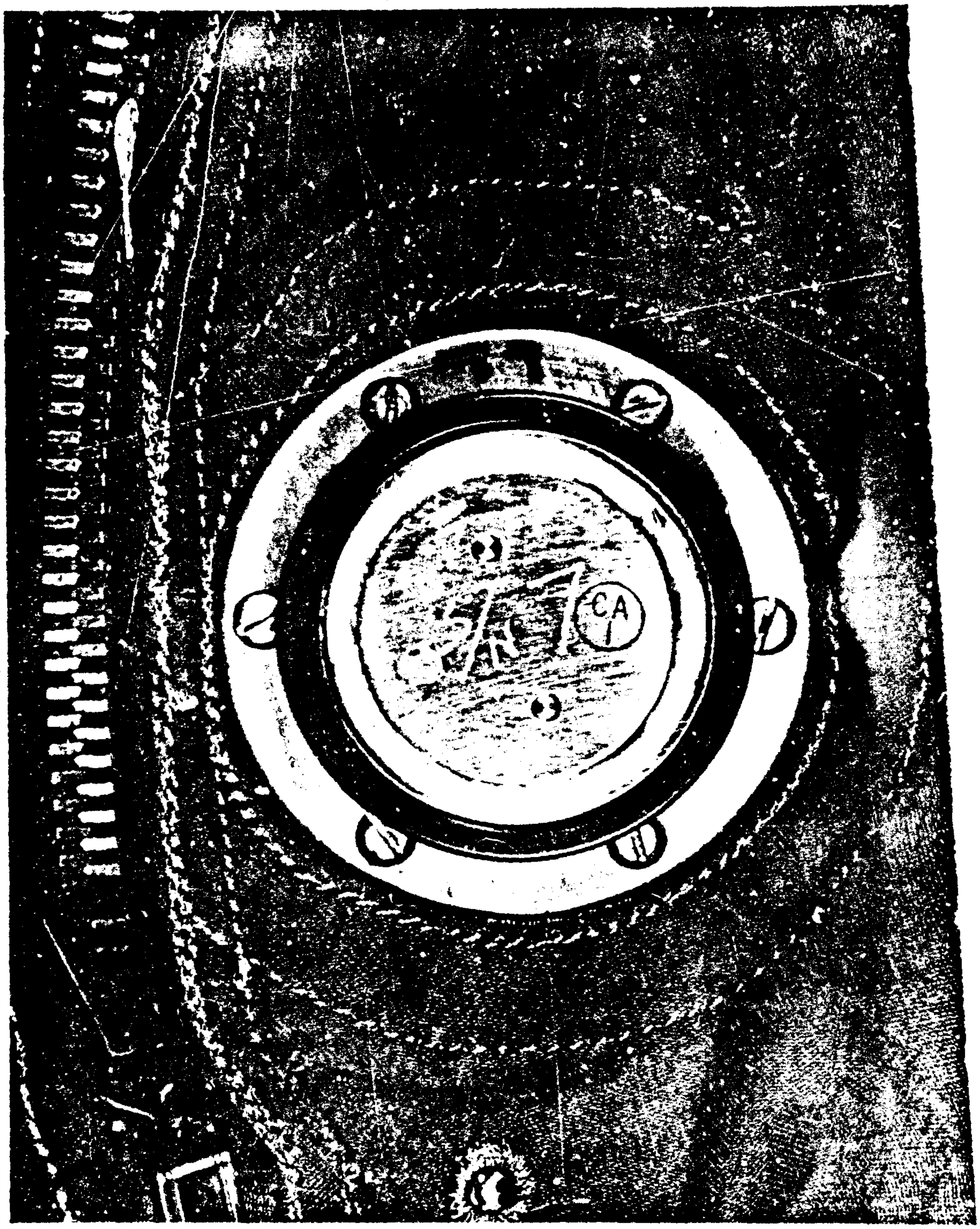


Figure 8. Top View of the USN Extremity Exhaust Valve (Installed in the Coverall)

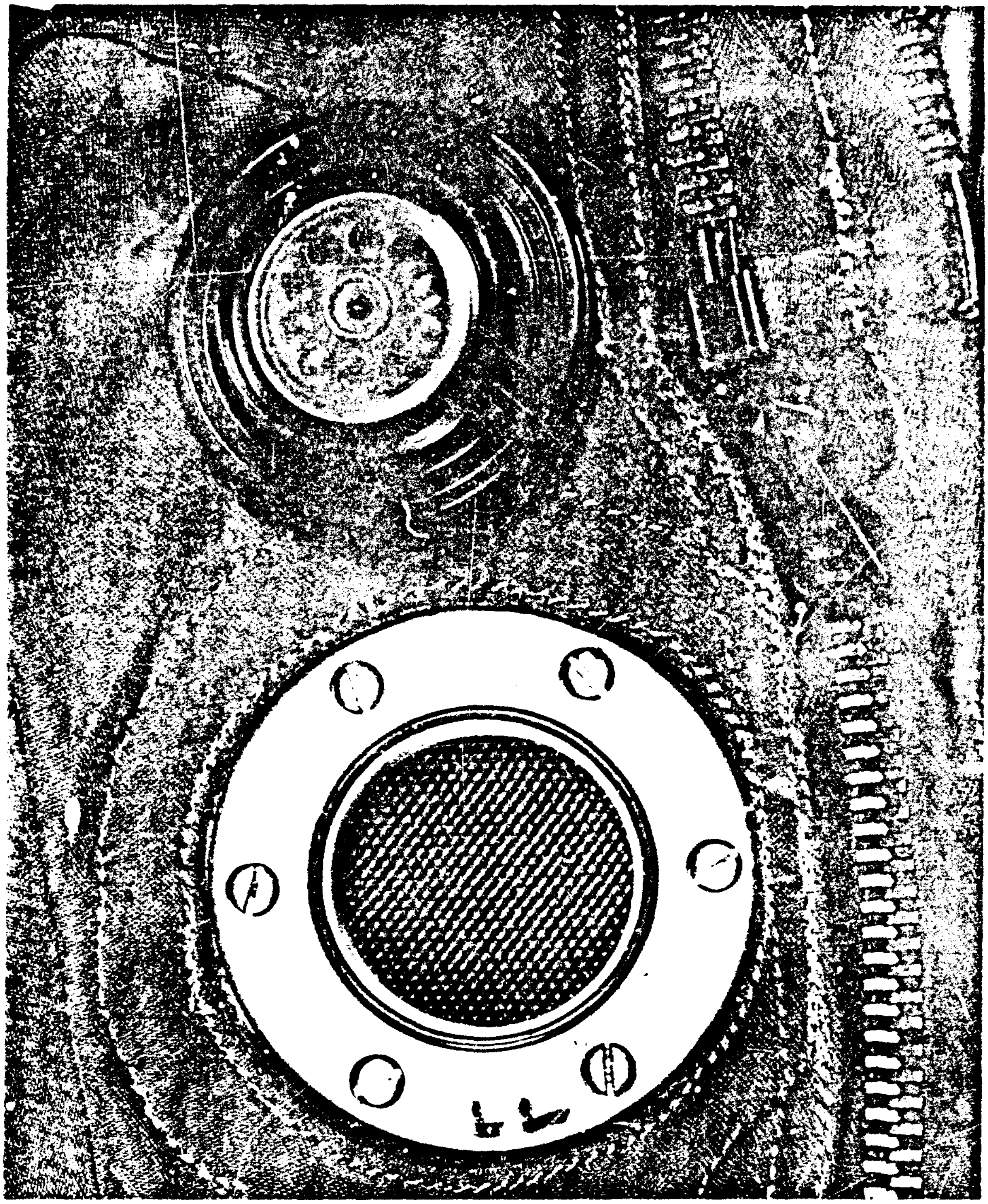


Figure 9. Bottom View of the USN Extremity Exhaust Valve (Shown Removed From Coverall)

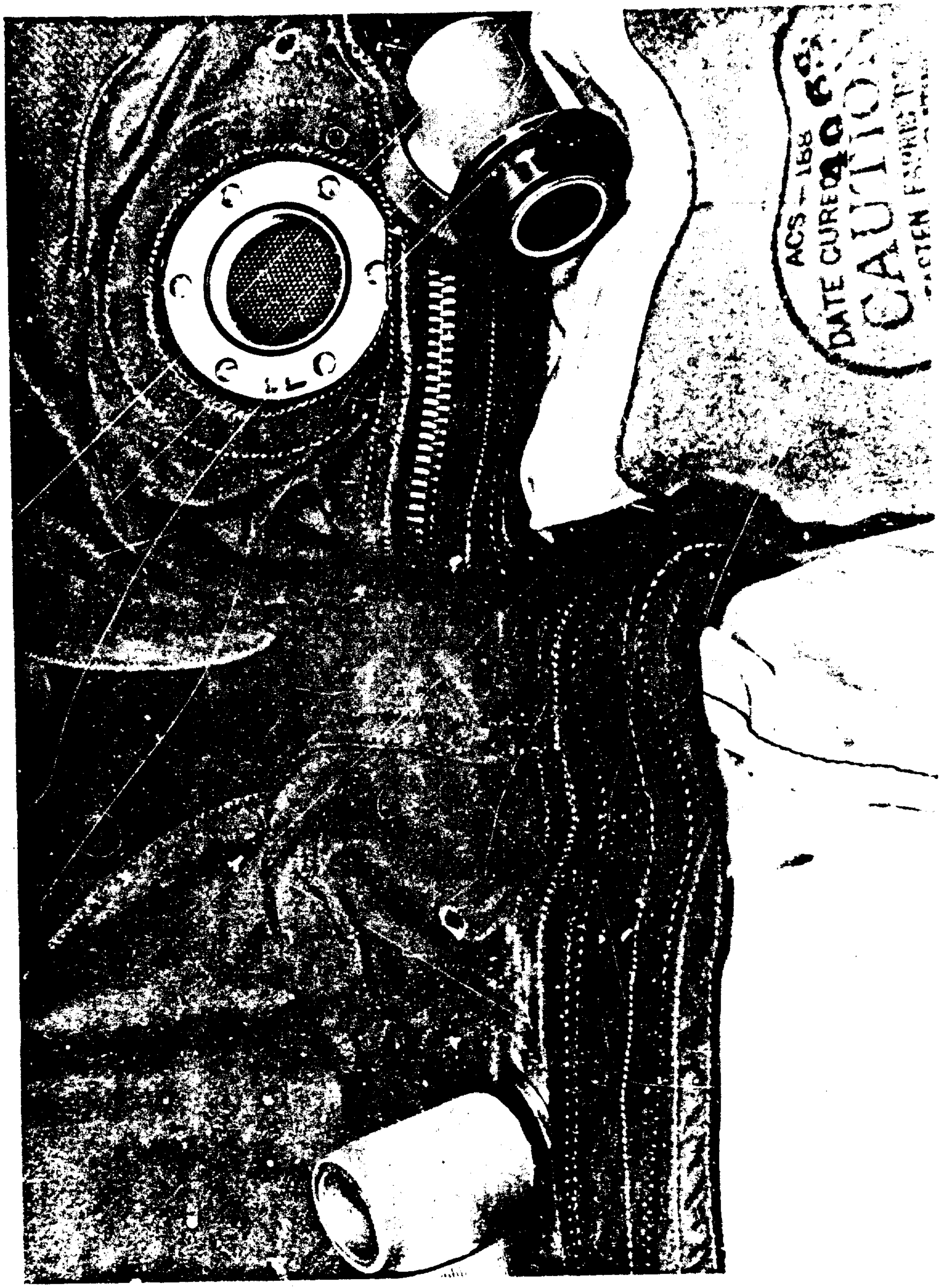


Figure 10. Modified Vent Flow Control Valve Used for Ground Level Control of Pressure in the Outfit

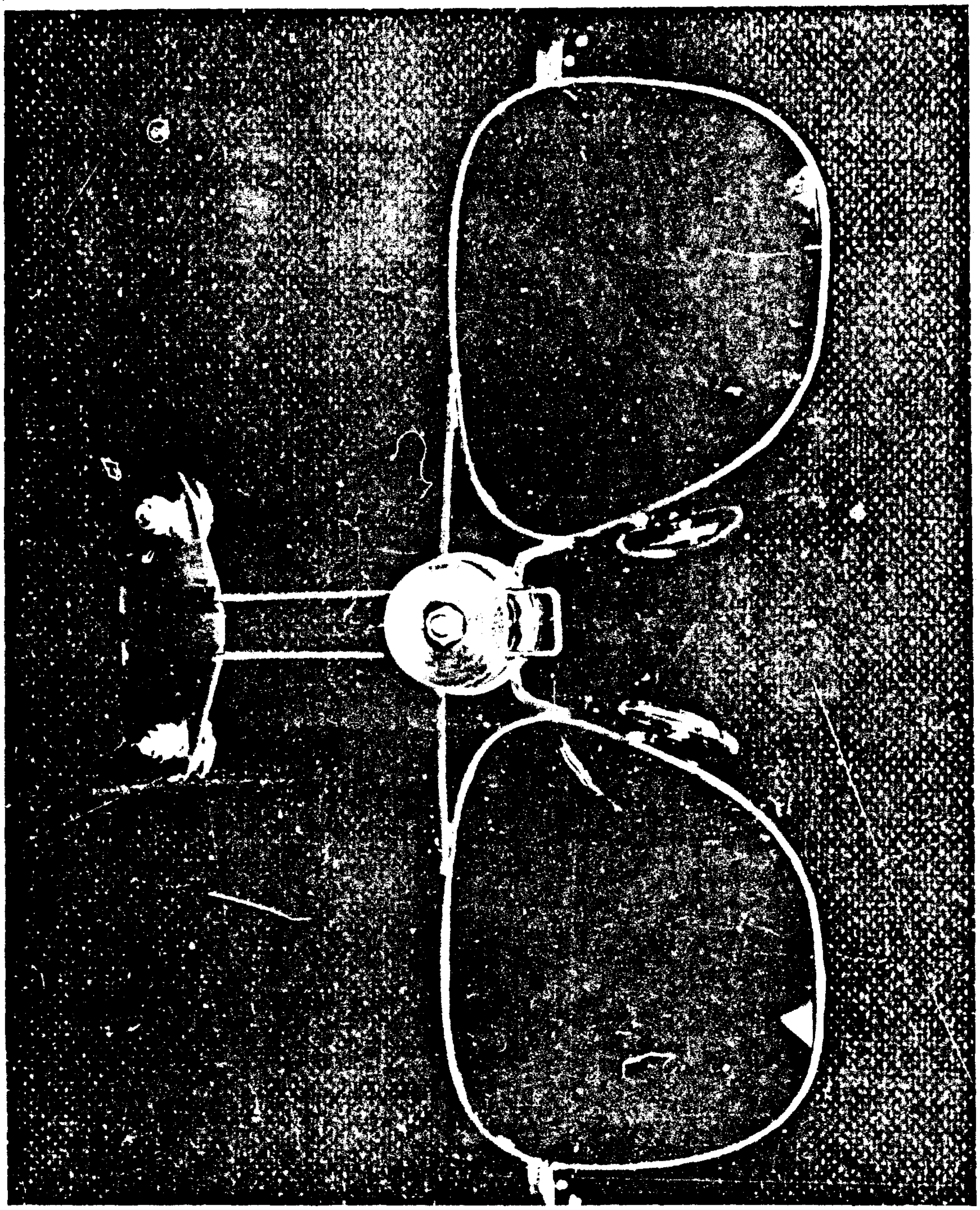


Figure 11. Modified HGU-4/P Sunglasses (USAF) for Use in A/P22S-2A (Mod 1) Helmet

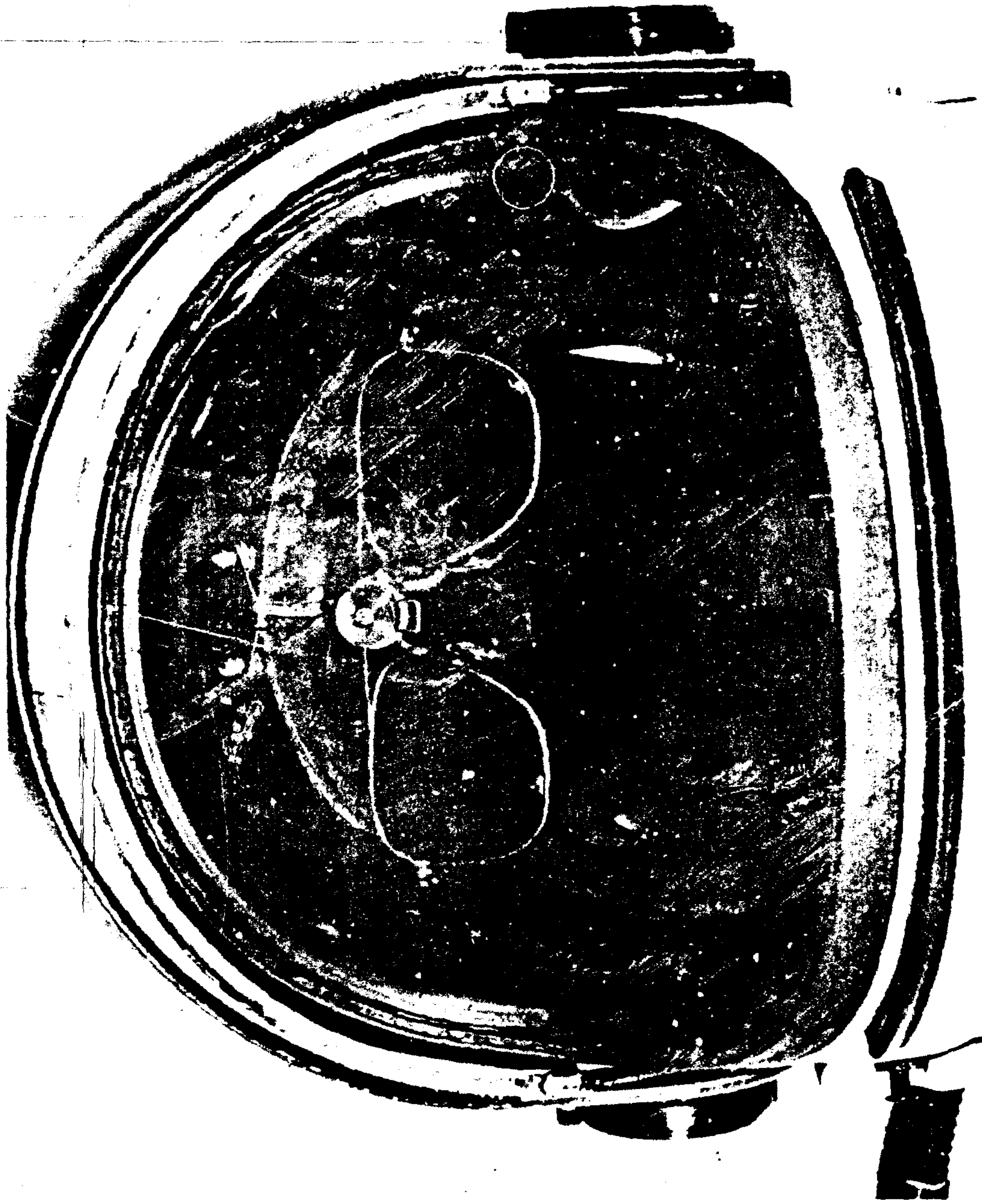


Figure 12. Modified HGU-4/P Sunglasses in Place on the A/P22S-2A (Mod 1) Helmet

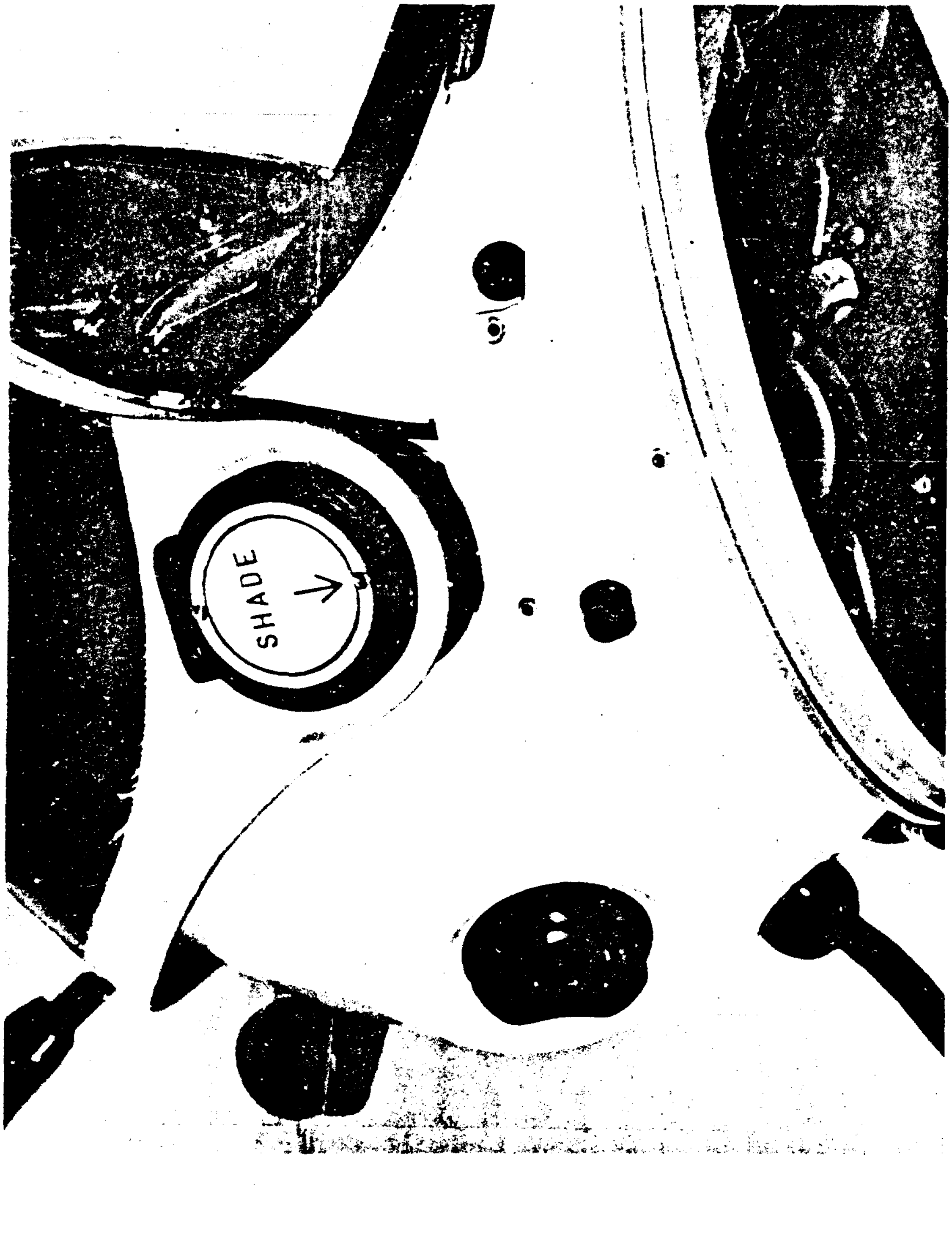


Figure 13. Visor Heater Wire and Cover

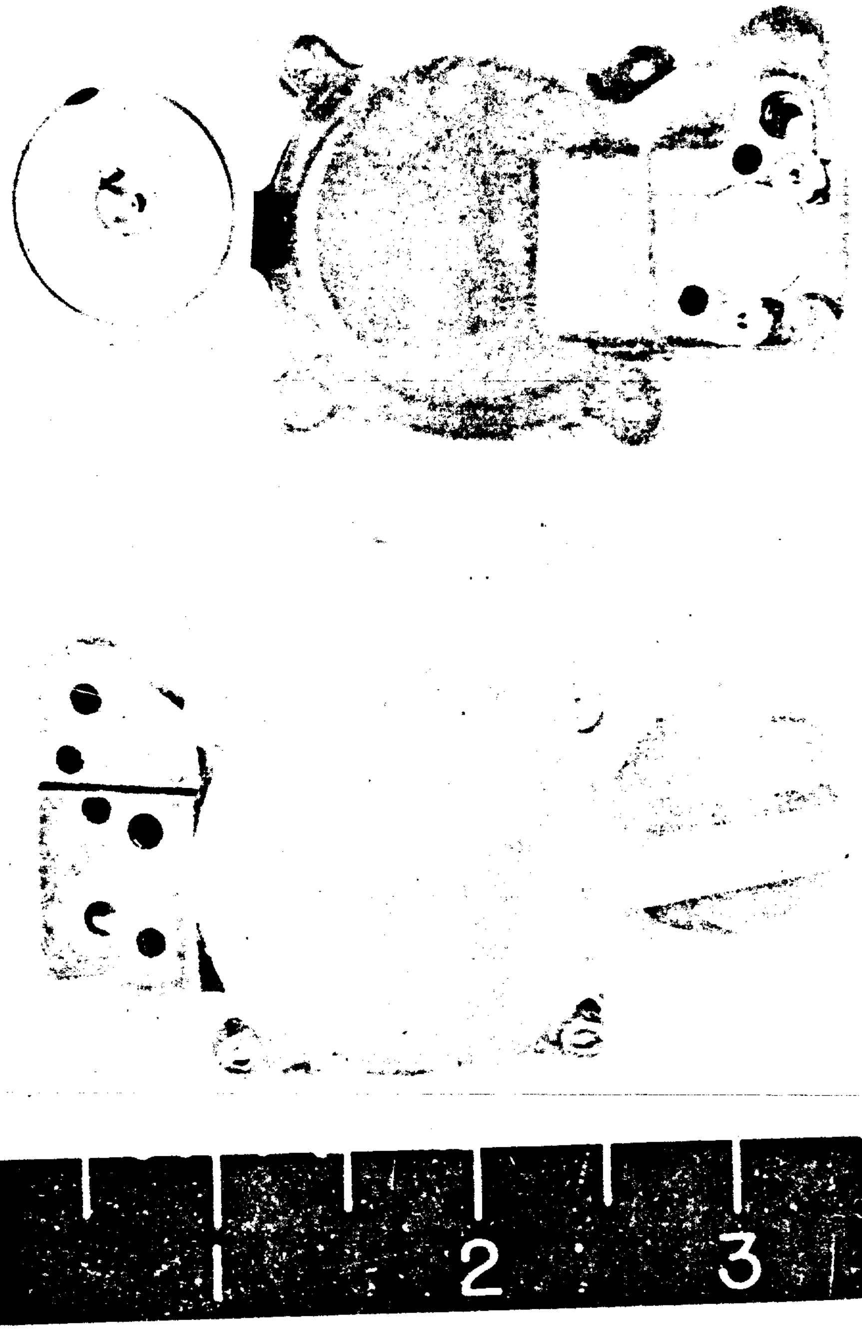


Figure 14. Oxygen Regulator With Emergency Makeup Valve

Figure 15. A/P22S-2A (Mod 1) Gloves

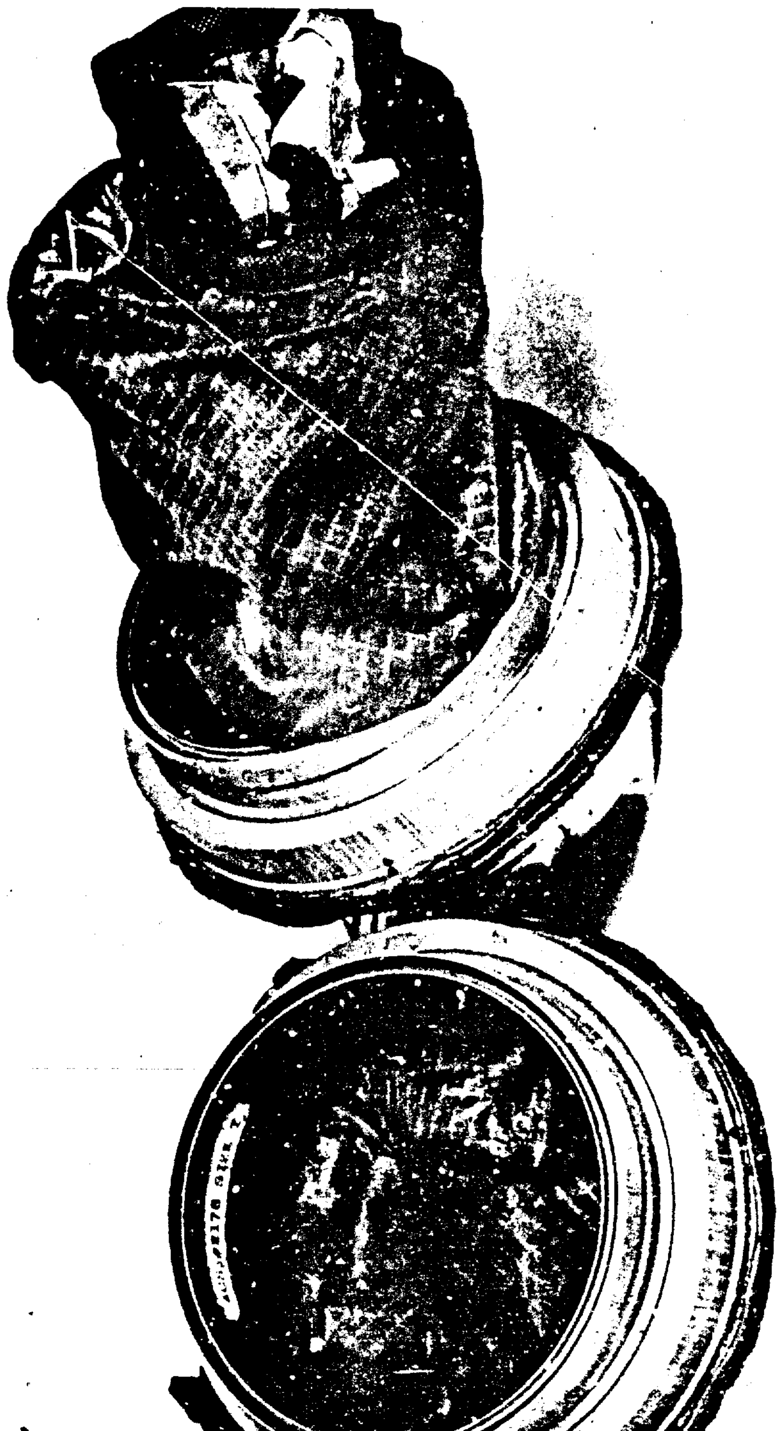


Figure 16. A/P22S-2A (Mod 1) Gloves Showing Vent Liner

Figure 17. A/P22S-2A (Mod 1) Gloves Showing Bladder and Restraint Layers

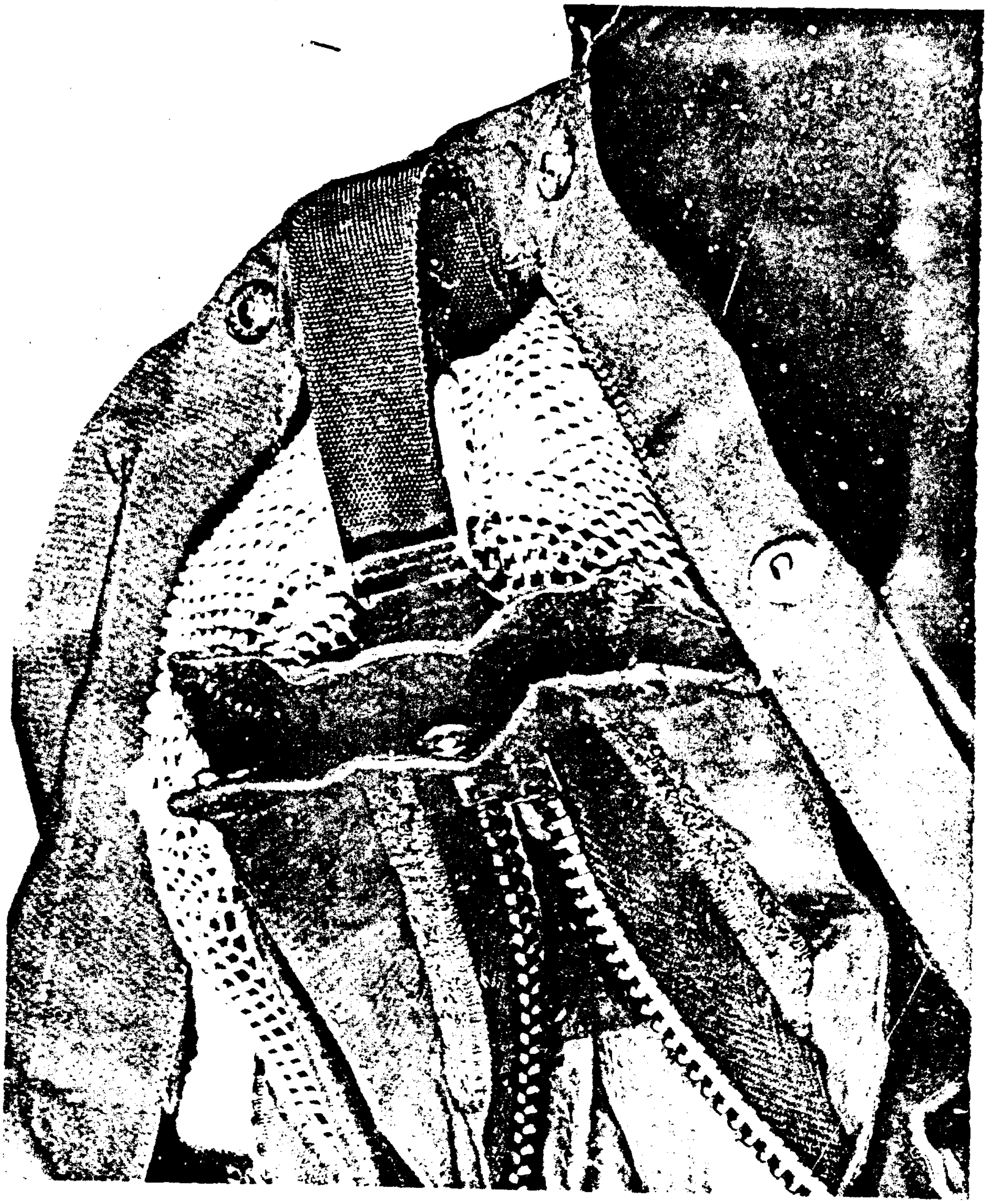


Figure 18. Attachment of Coverall Outer Layer to Coverall Showing Entry Slide Fastener and Helmet Holddown Attachment

Figure 19. Coverall Vent Liner Showing Controller Antiblock and Pressure Relief Valve

Figure 20. Lower Leg Section of Coverall Liner Showing Nylon Mesh Ventilation Air Outlet at Toes and Exhaust Valve Triloc Antiblock

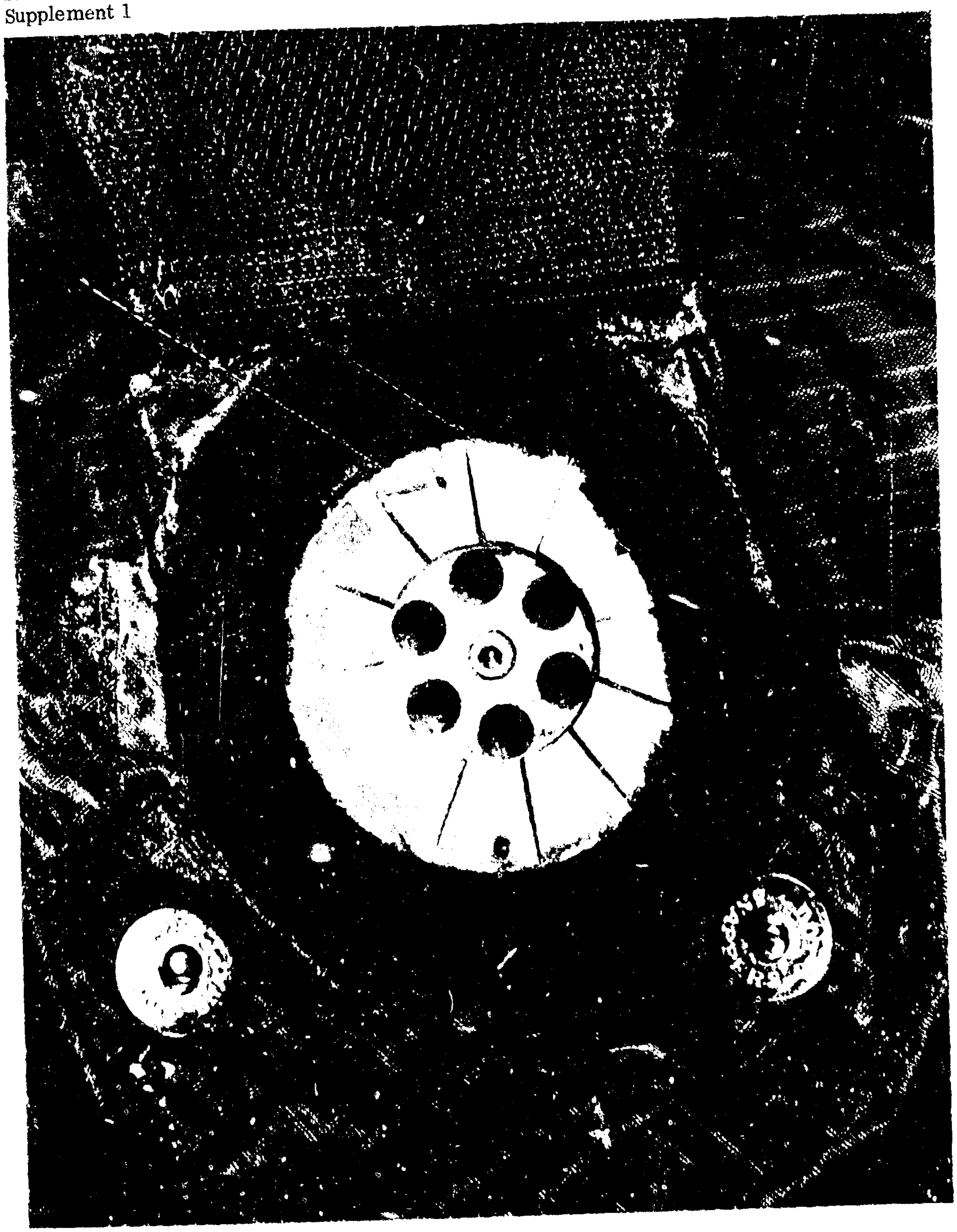


Figure 21. Pressure Relief Valve and Antiblock

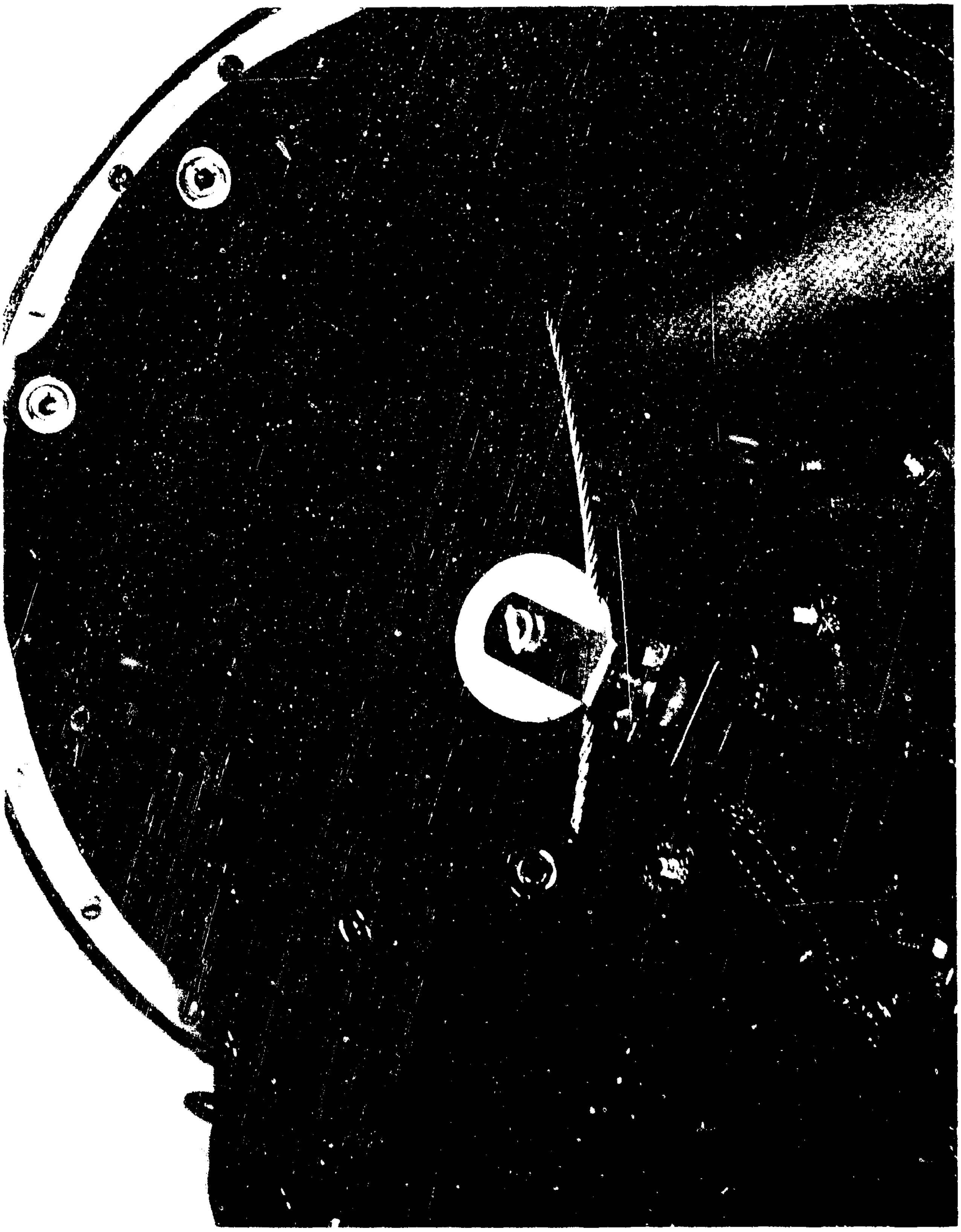


Figure 22. Flap Cover of A/P22S-2A (Mod 1) Outfit for Back Holddown Pulley and End of Entry Slide Fastener

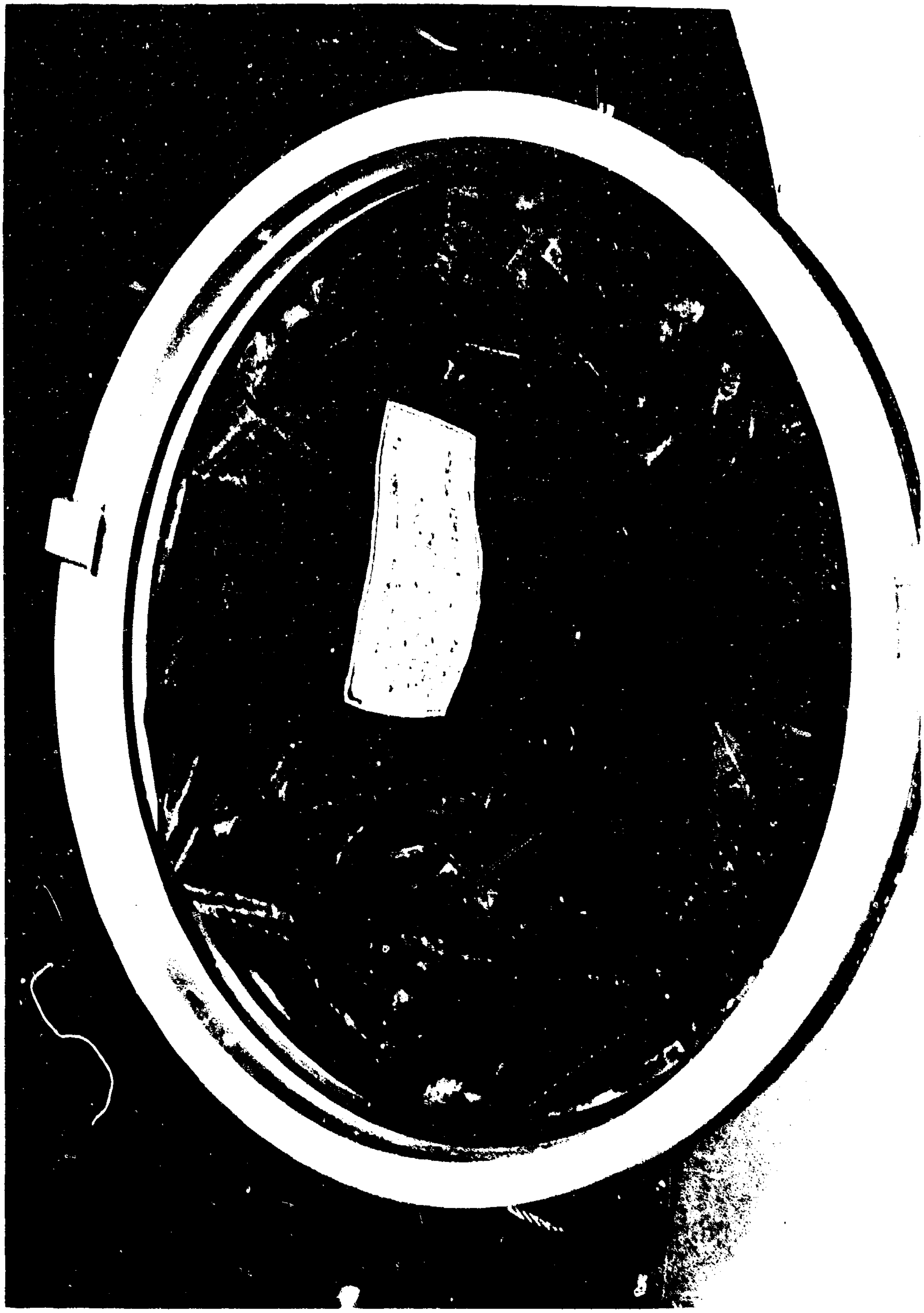


Figure 23. Neck Ring Disconnect of A/P22S-2A (Mod 1) Outfit

Figure 24. Wrist Ring Bearing Disconnects

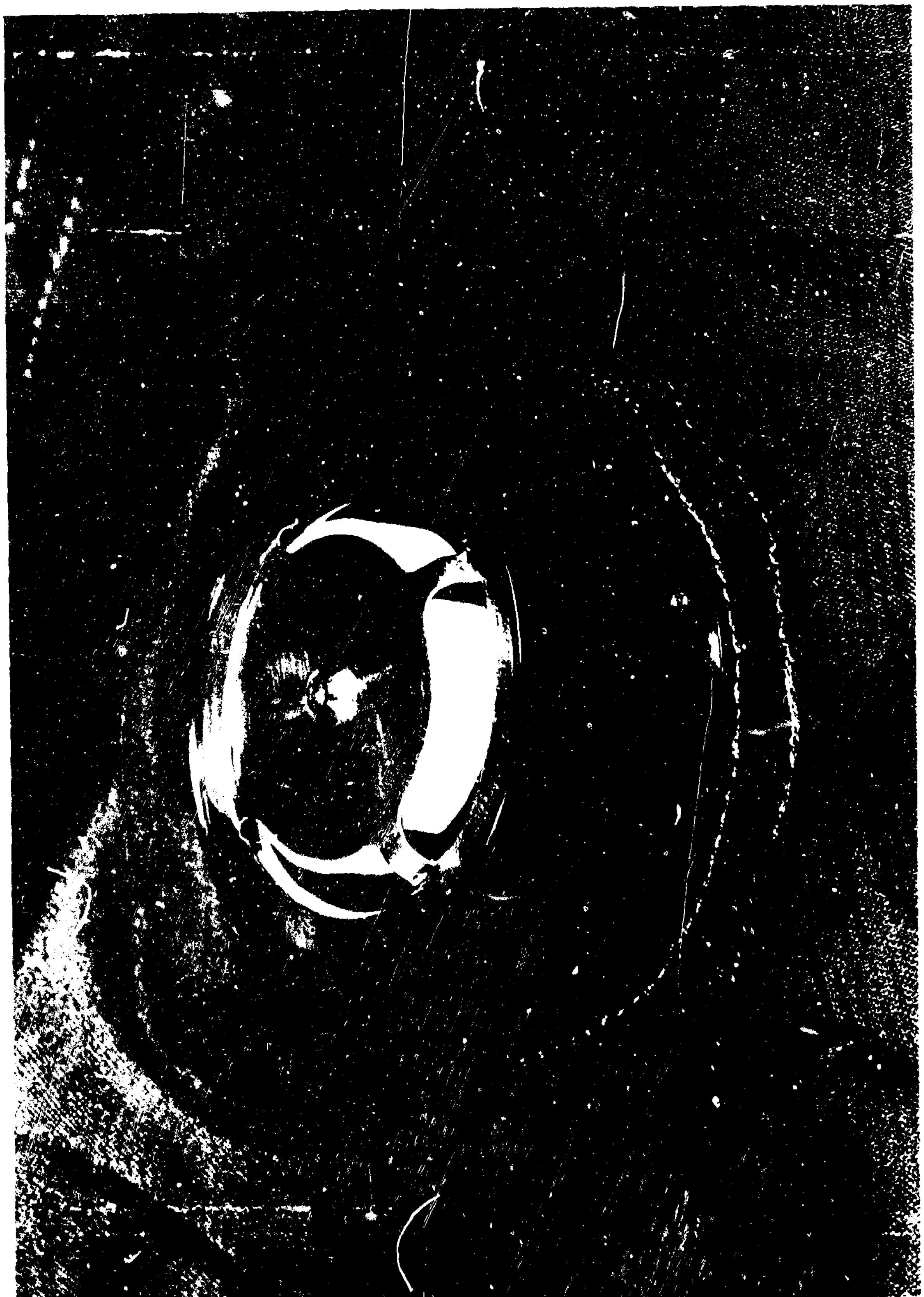
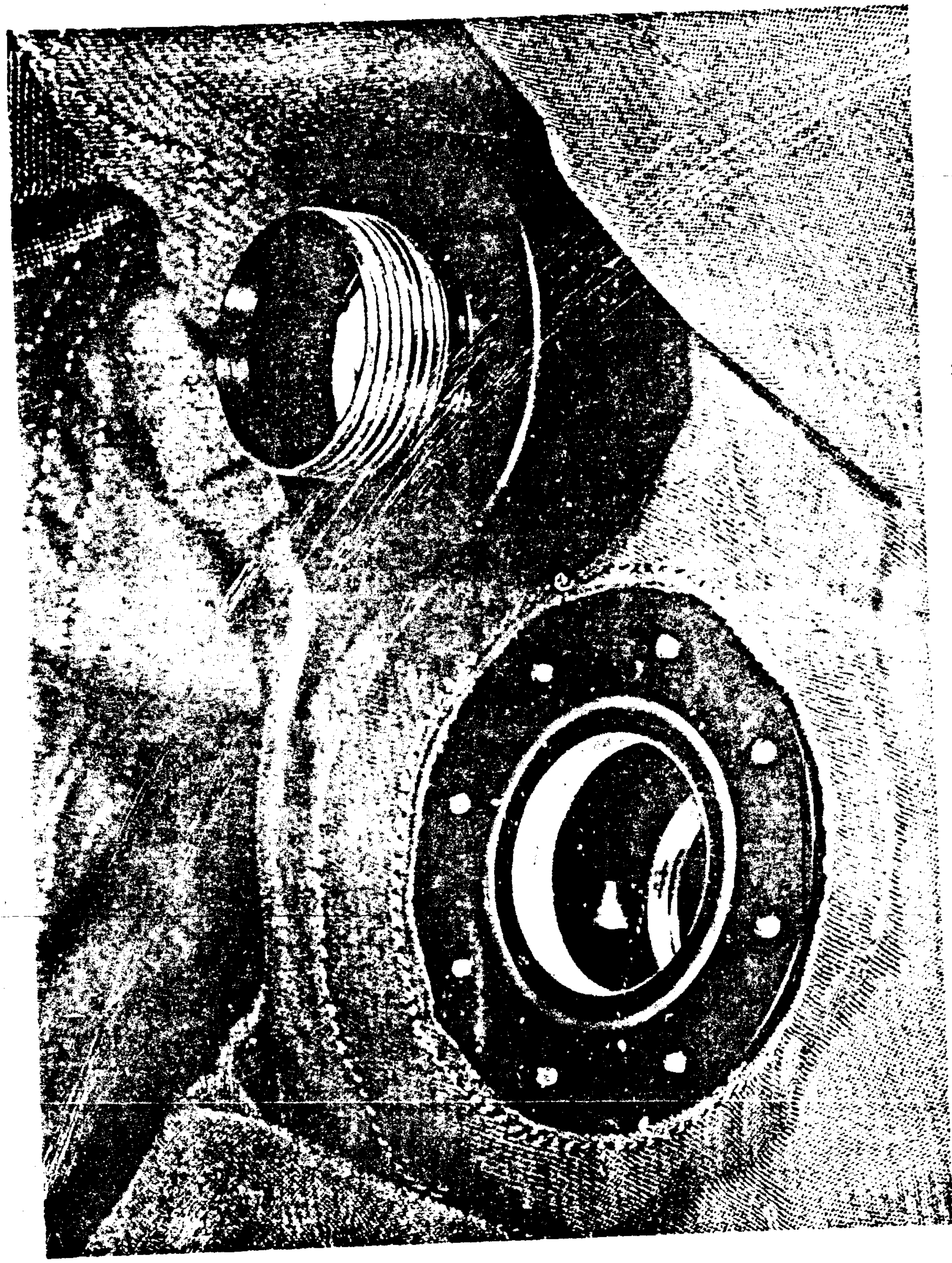


Figure 25. Controller Mounted in Coverall



[illegible] Controller Removed From Coverall

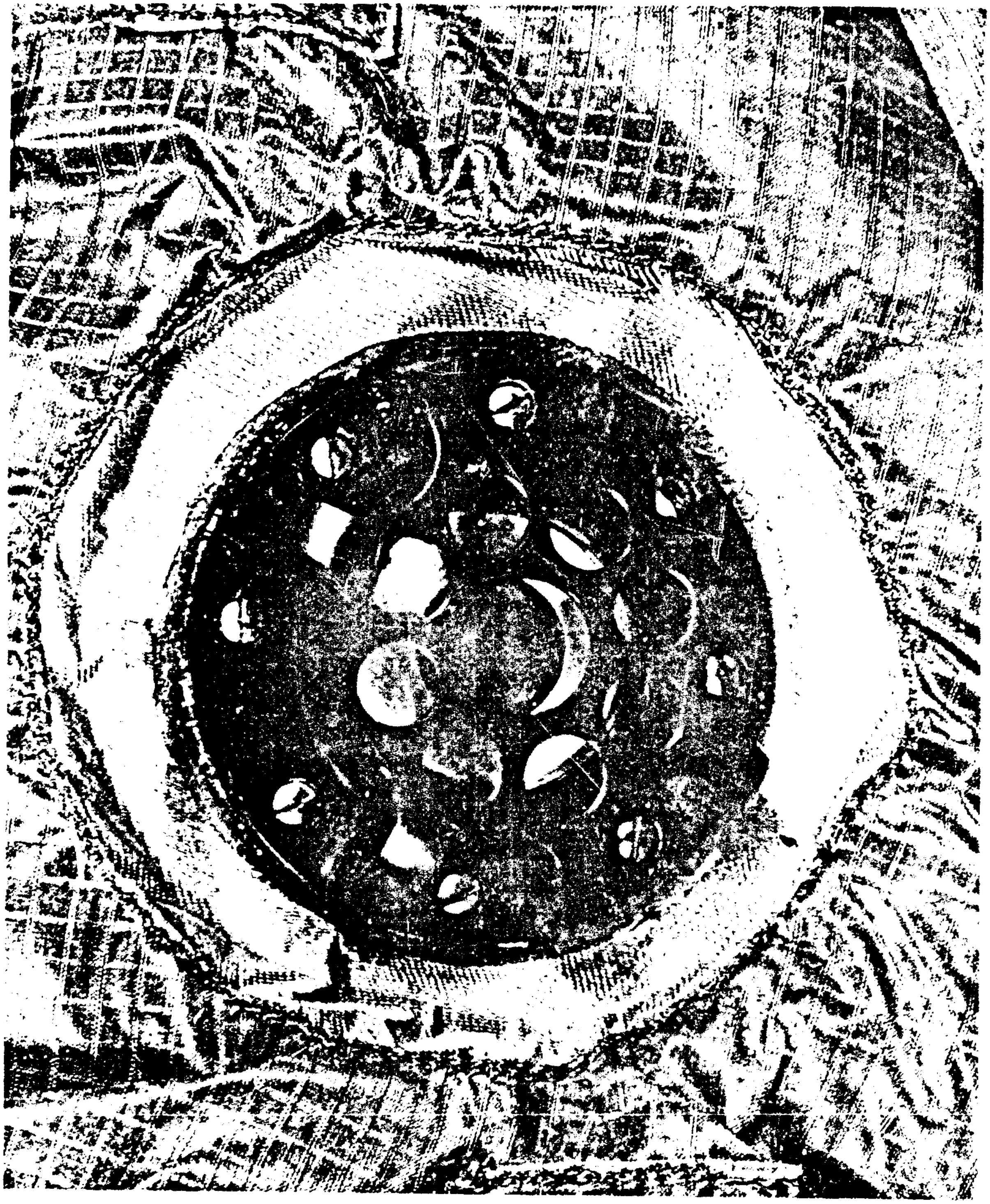


Figure 27. Controller Basket Antiblock (Triloc Removed)

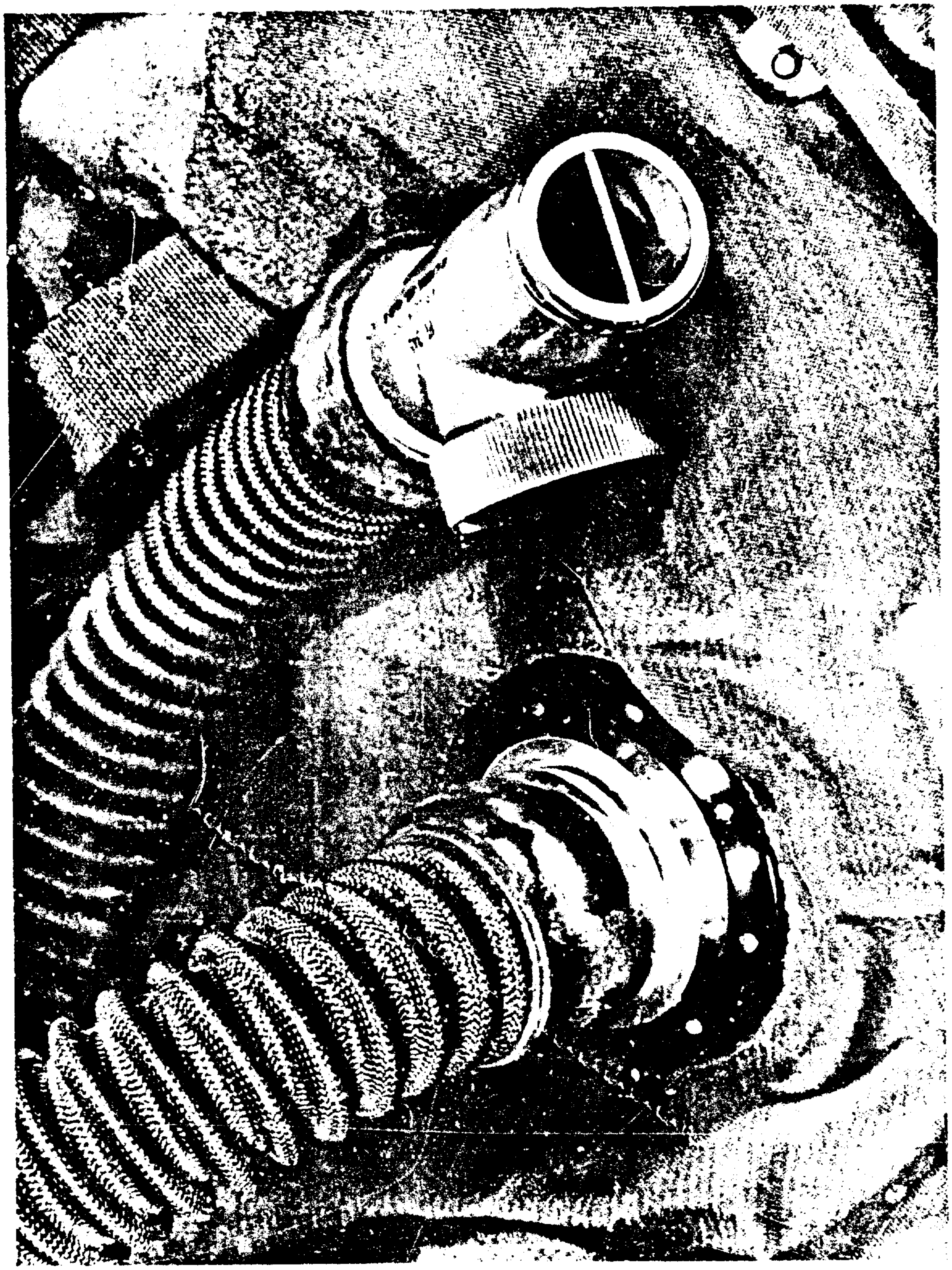


Figure 28. Loading Valve for Pressurizing Outfit at Ground Level (Shown Attached to Coverall at Controller

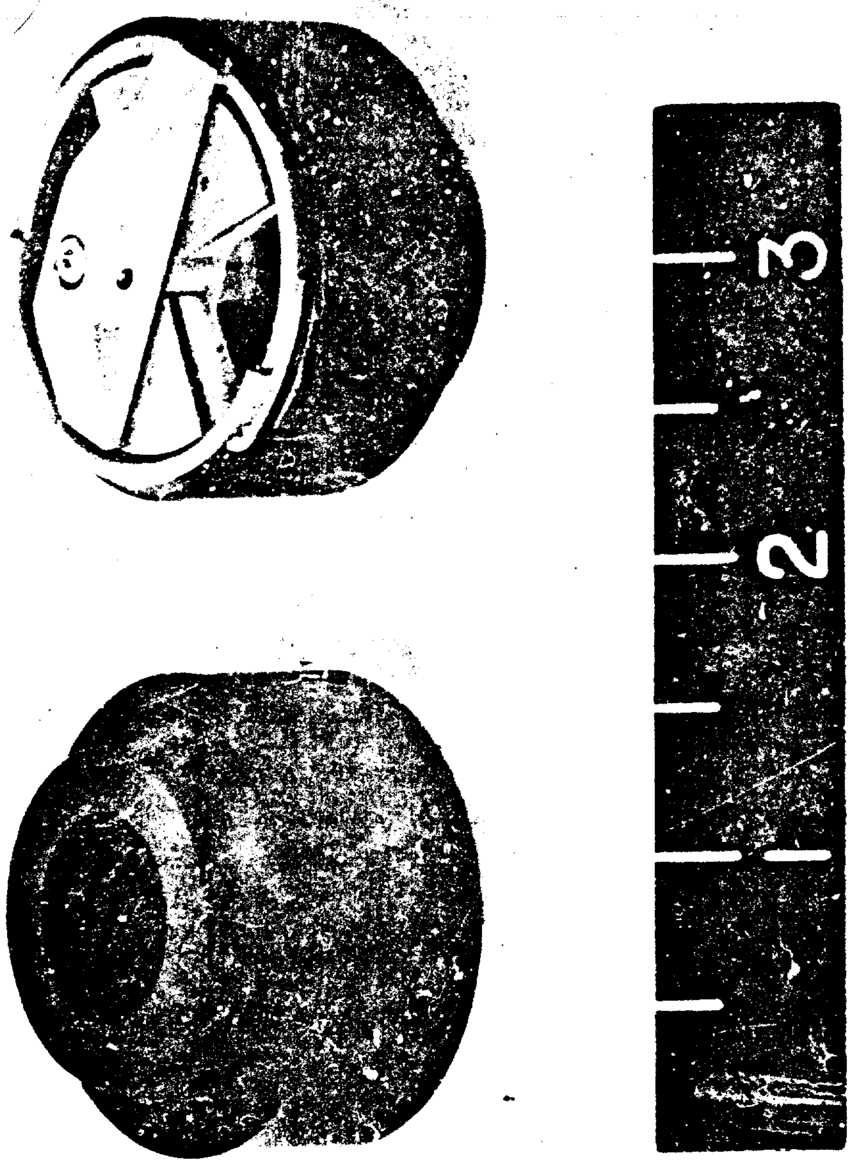


Figure 29. Modified Ventilation Air Exhaust Control Valve

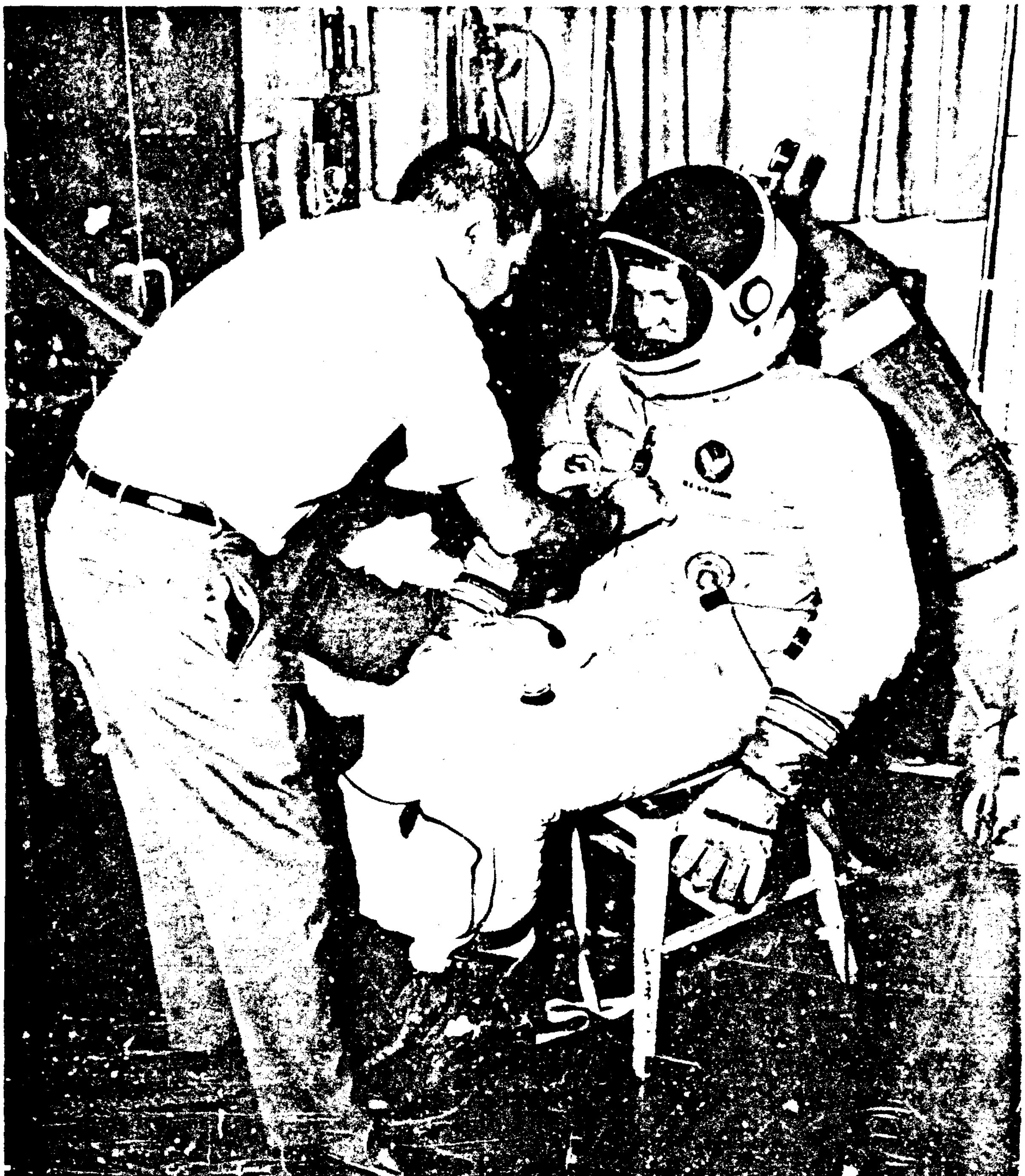


Figure 30. Technique for Measurement of Chest Circumference

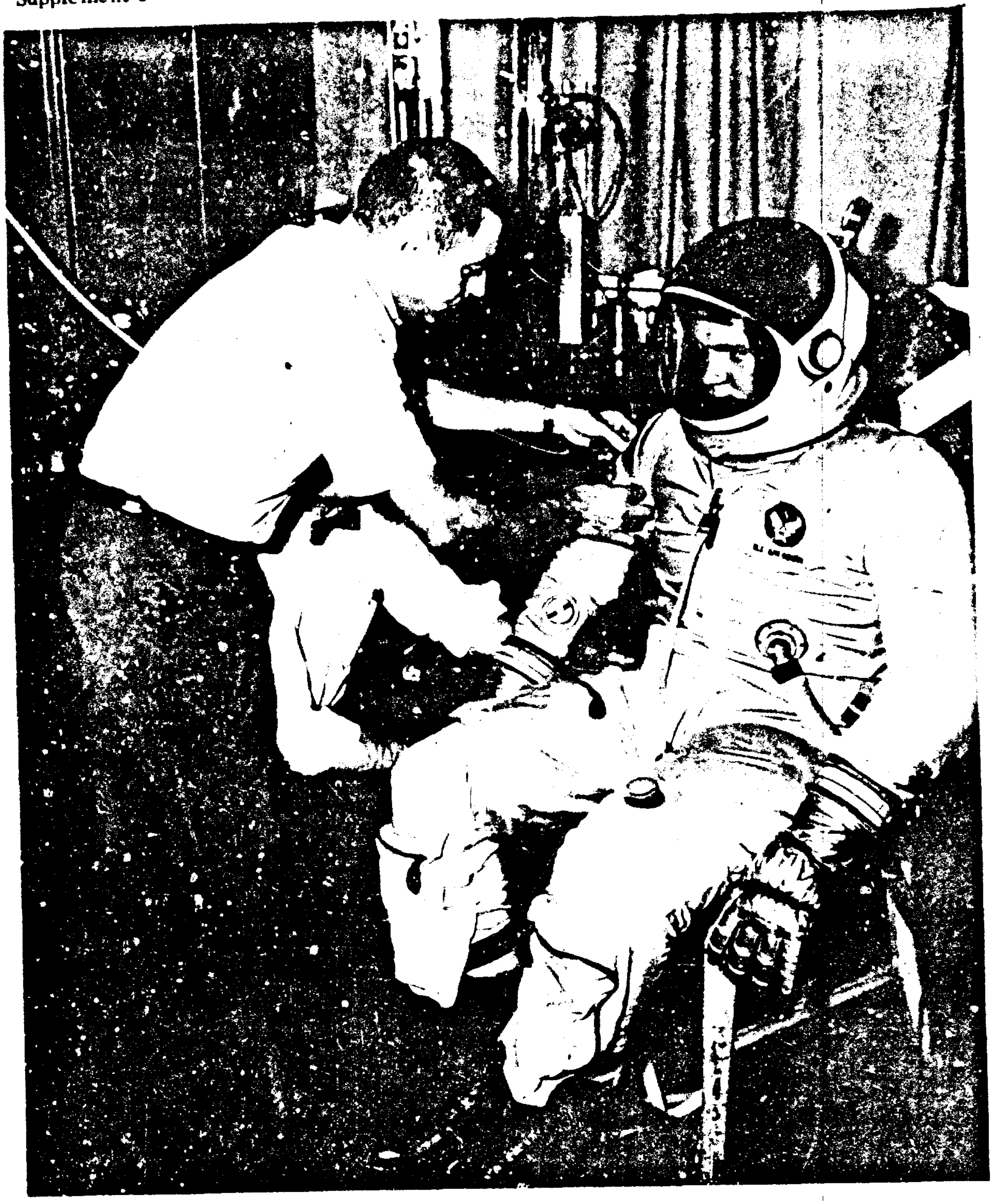


Figure 31. Technique for Measurement of Arm Circumference

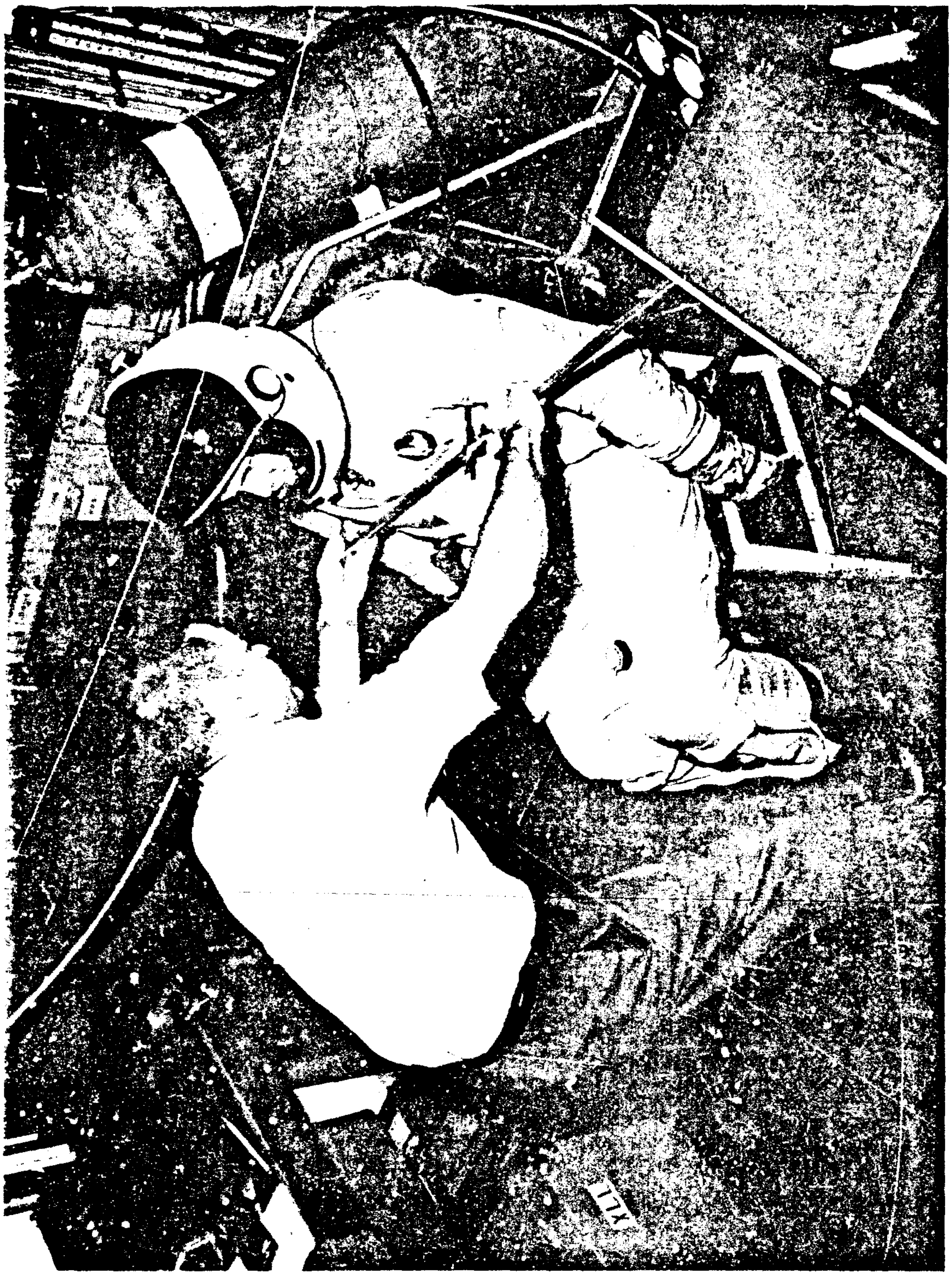


Figure 33. Technique for Use of Anthropometer for Breadth Measurement

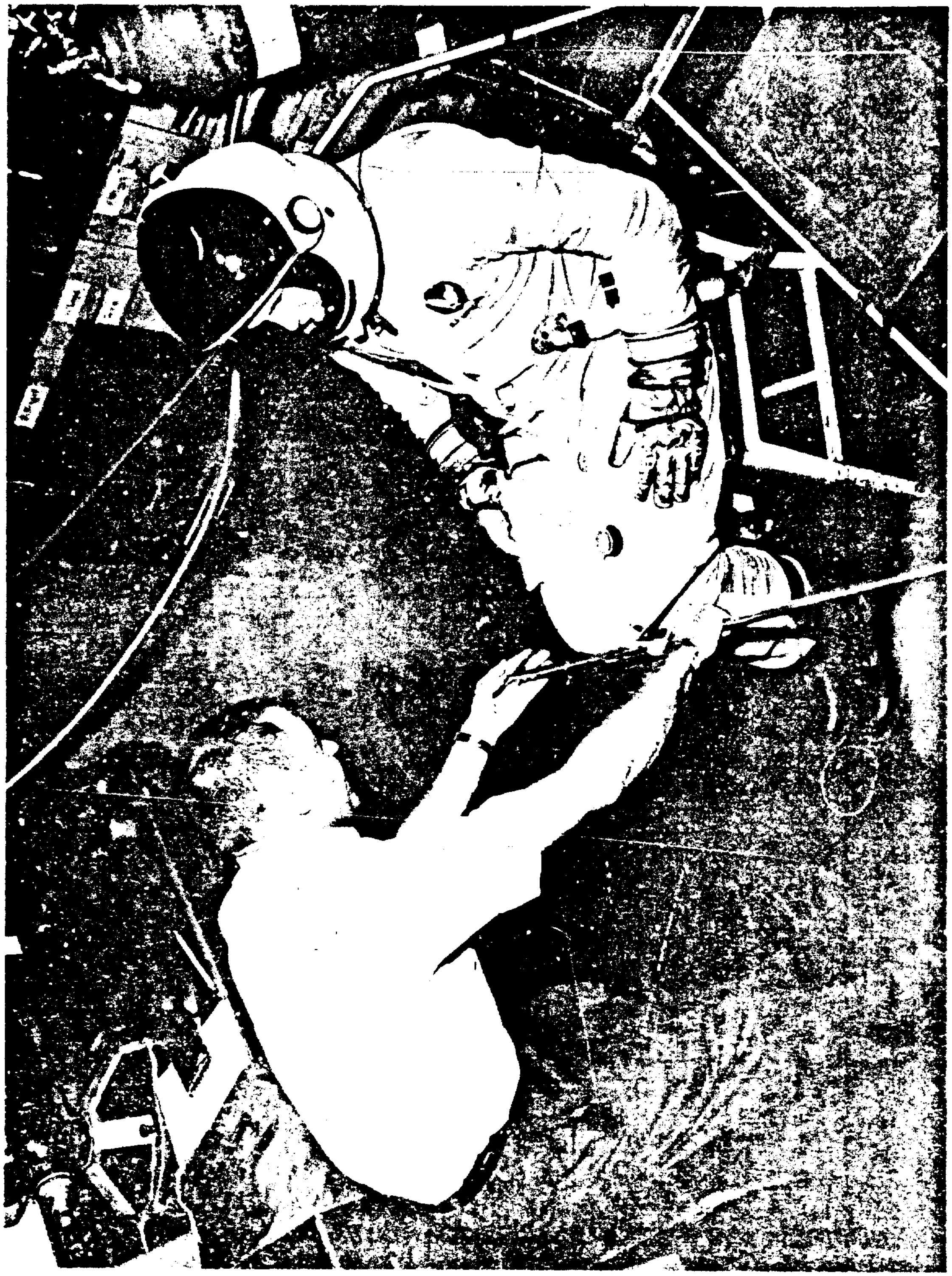


Figure 24   Technique for Use of Anthropometer for Breadth Measurement

Figure 35. Hand Dexterity Evaluation

Figure 37. Left Side View of the Outfit Being Used on the Work-Space Evaluator

Figure 38. Right Side View of the Outfit Being Used on the Work-Space Evaluator

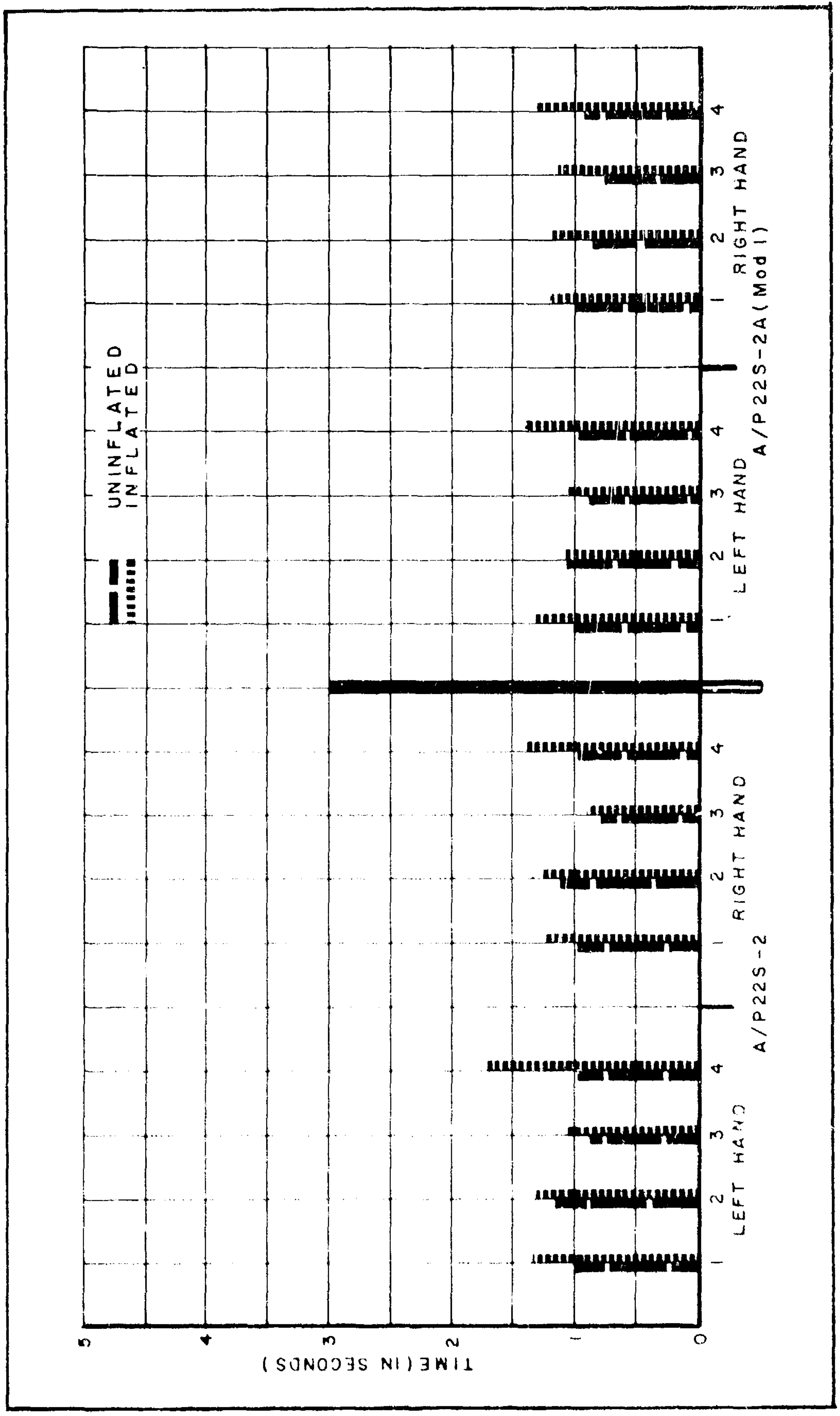


Figure 39. Comparison of Total Operation Time for the A/P22S-2 and A/P22S-2A (Mod 1) Outfits

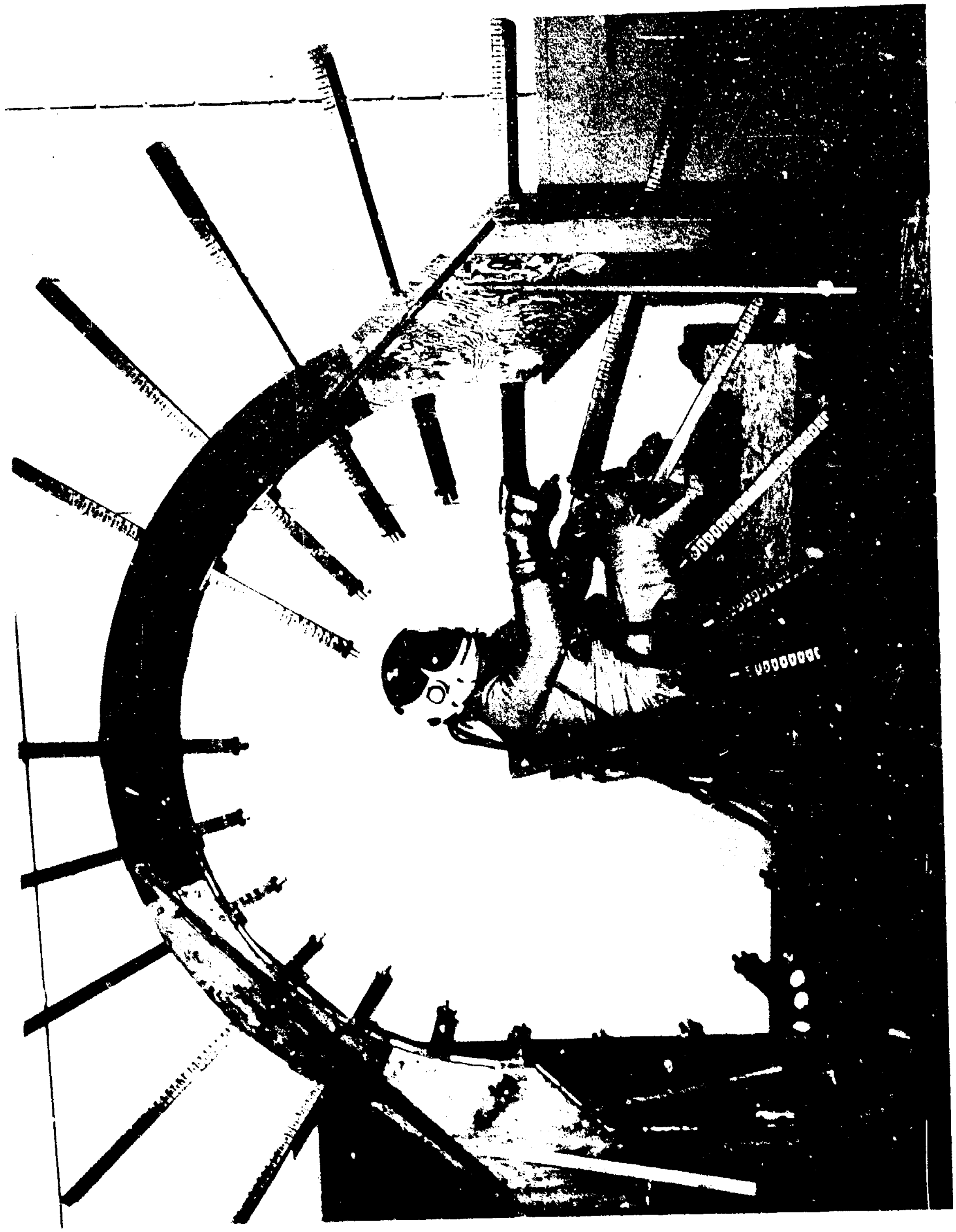


Figure 40. Reach Capability Arrangement: Right Side View of Outfit Pressurized to 3.5 psig

Figure [illegible]. Bench Capability Arrangement: Front View of Outfit Pressurized to 3.5 psig

Figure 42. Reach Capability Arrangement: Left Side View of Outfit Pressurized to 3.5 psig

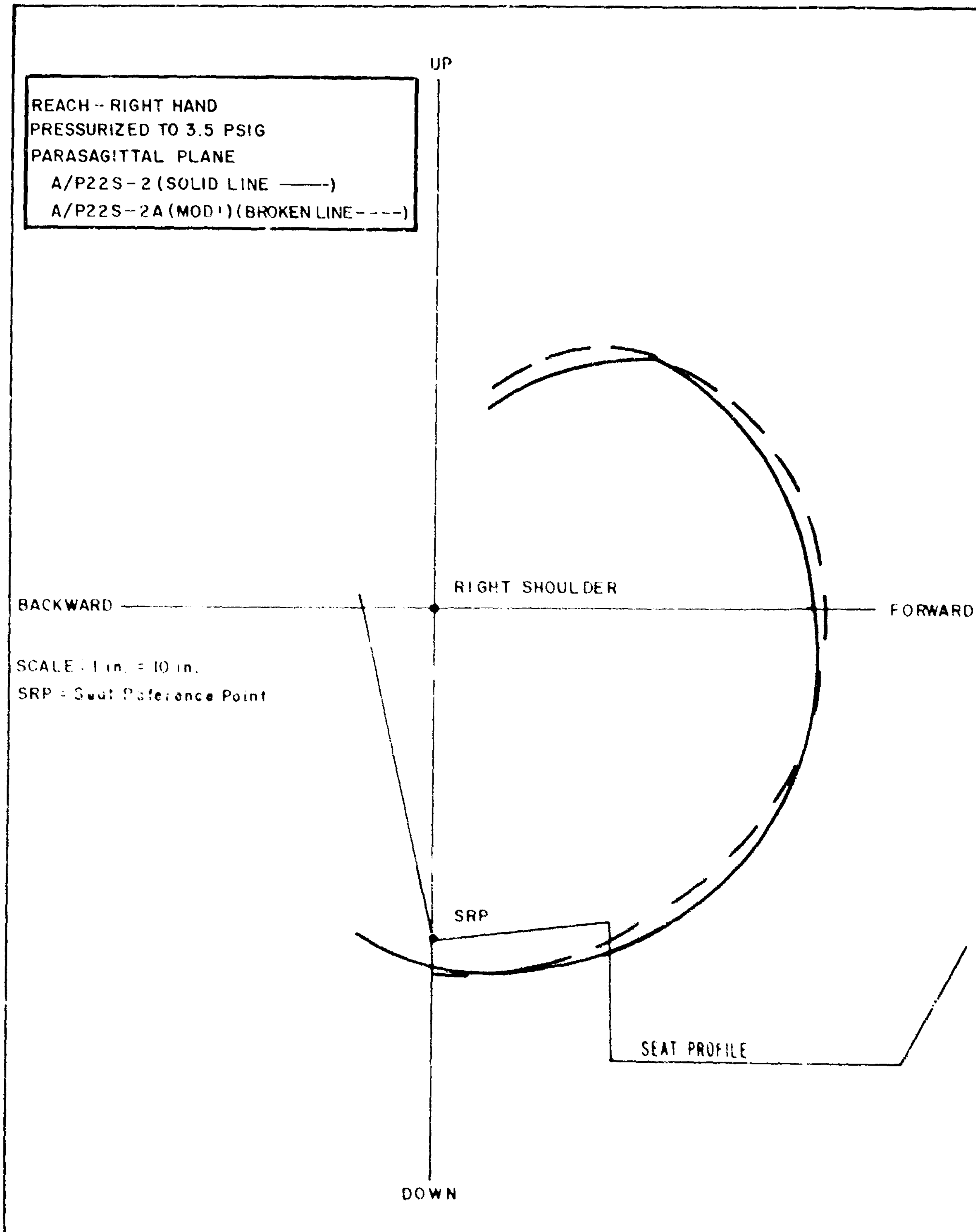


Figure 43. Reach Capability Contours

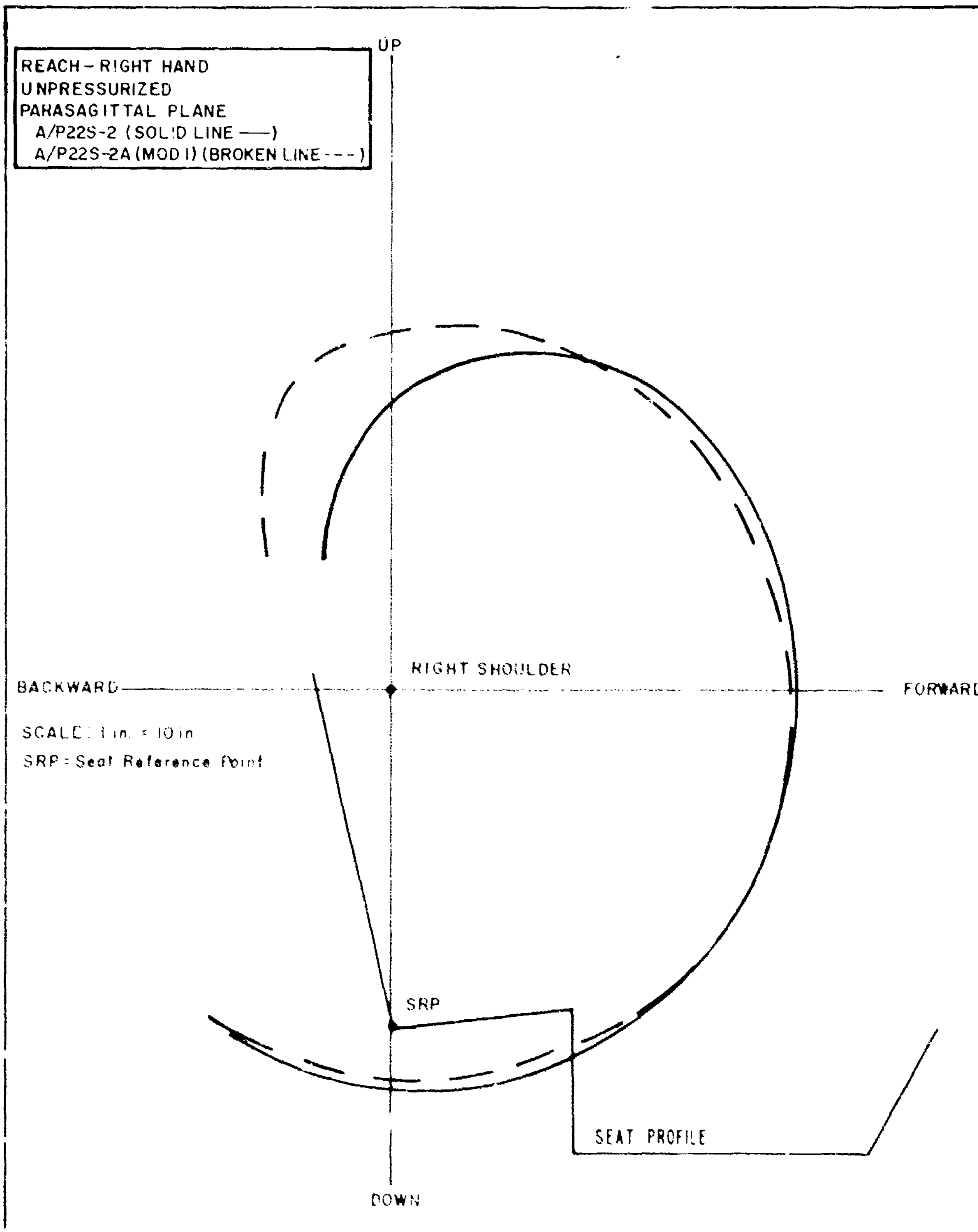


Figure 44. Reach Capability Contours

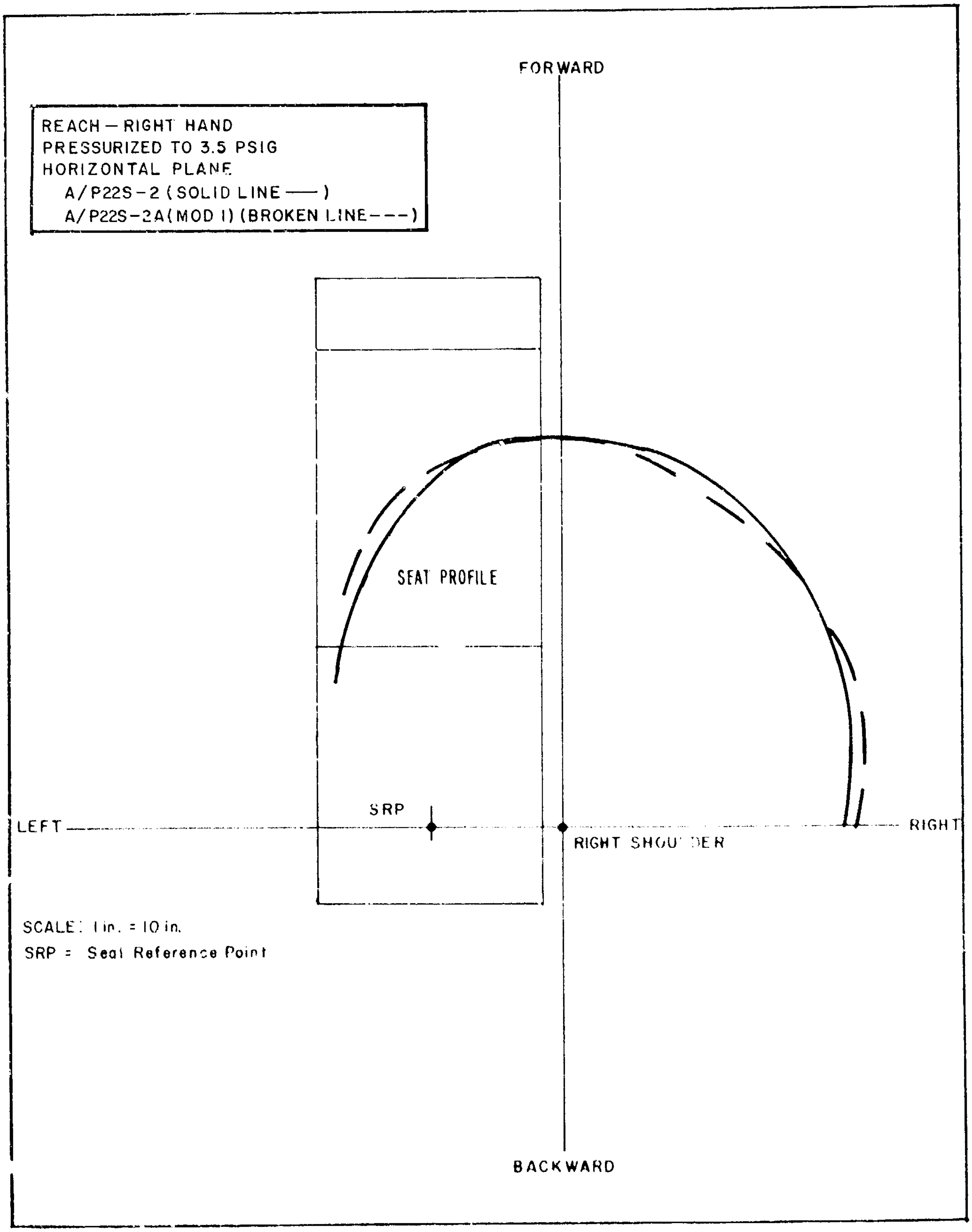


Figure 45. Reach Capability Contours

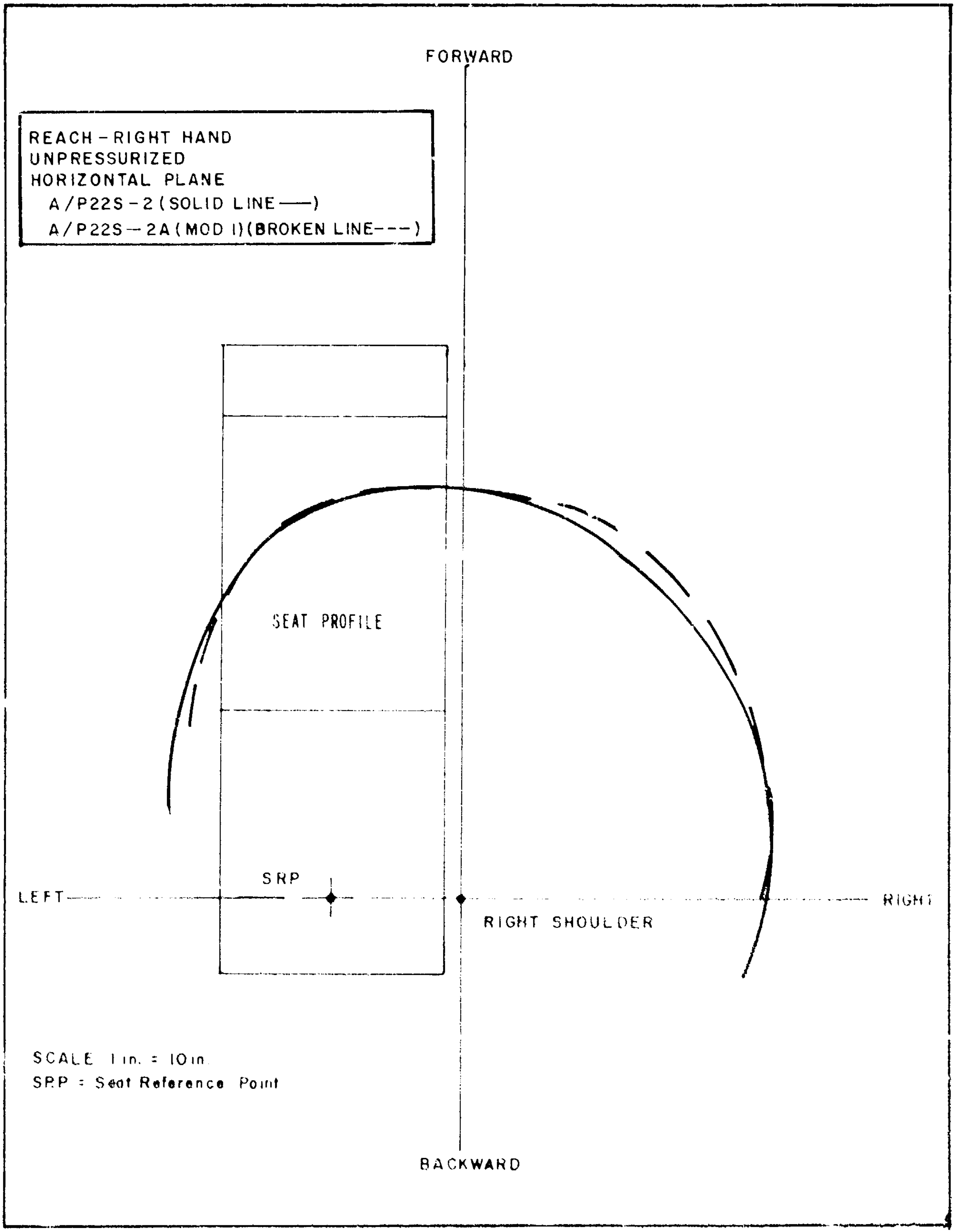


Figure 46. Reach Capability Contours

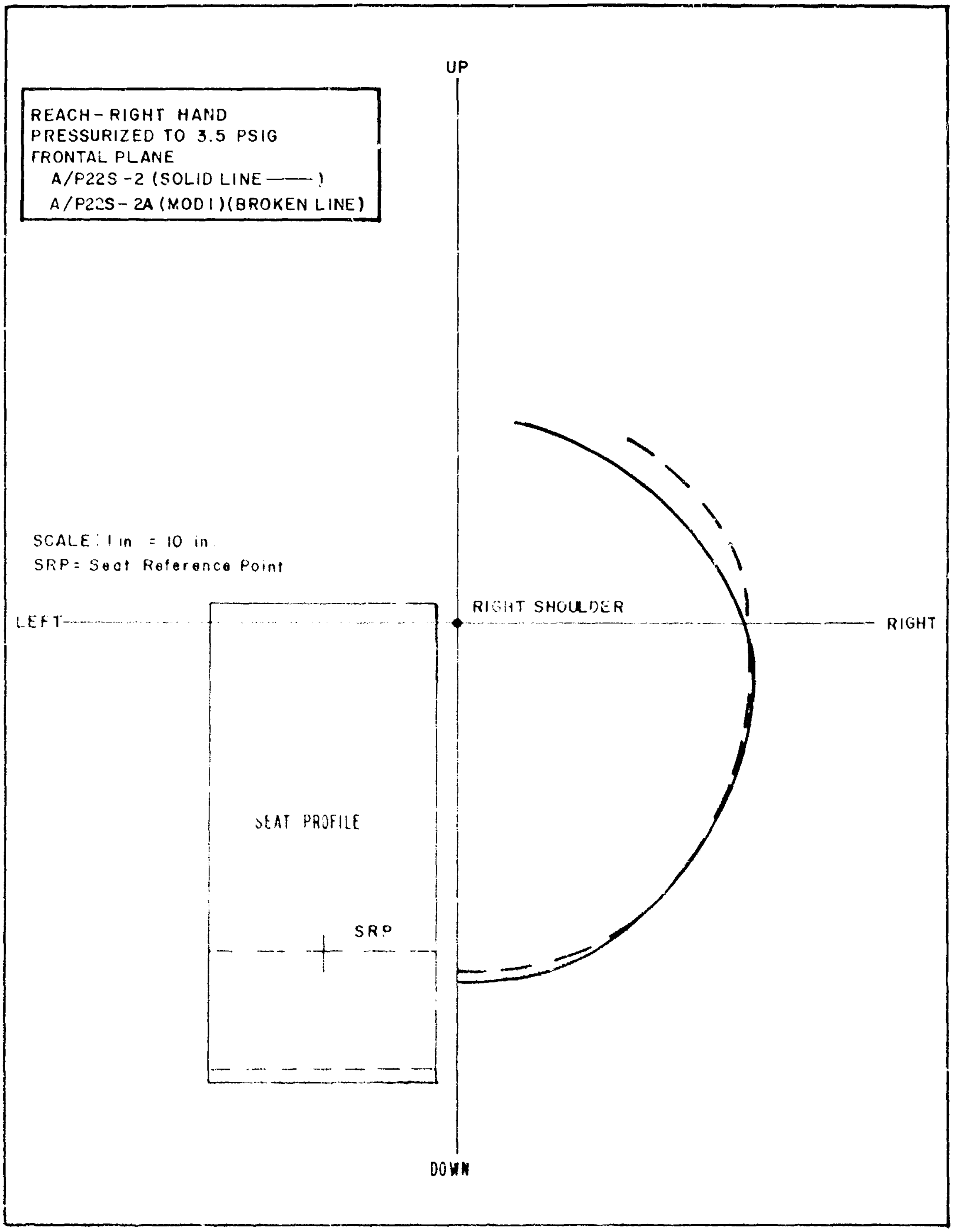


Figure 47. Reach Capability Contours

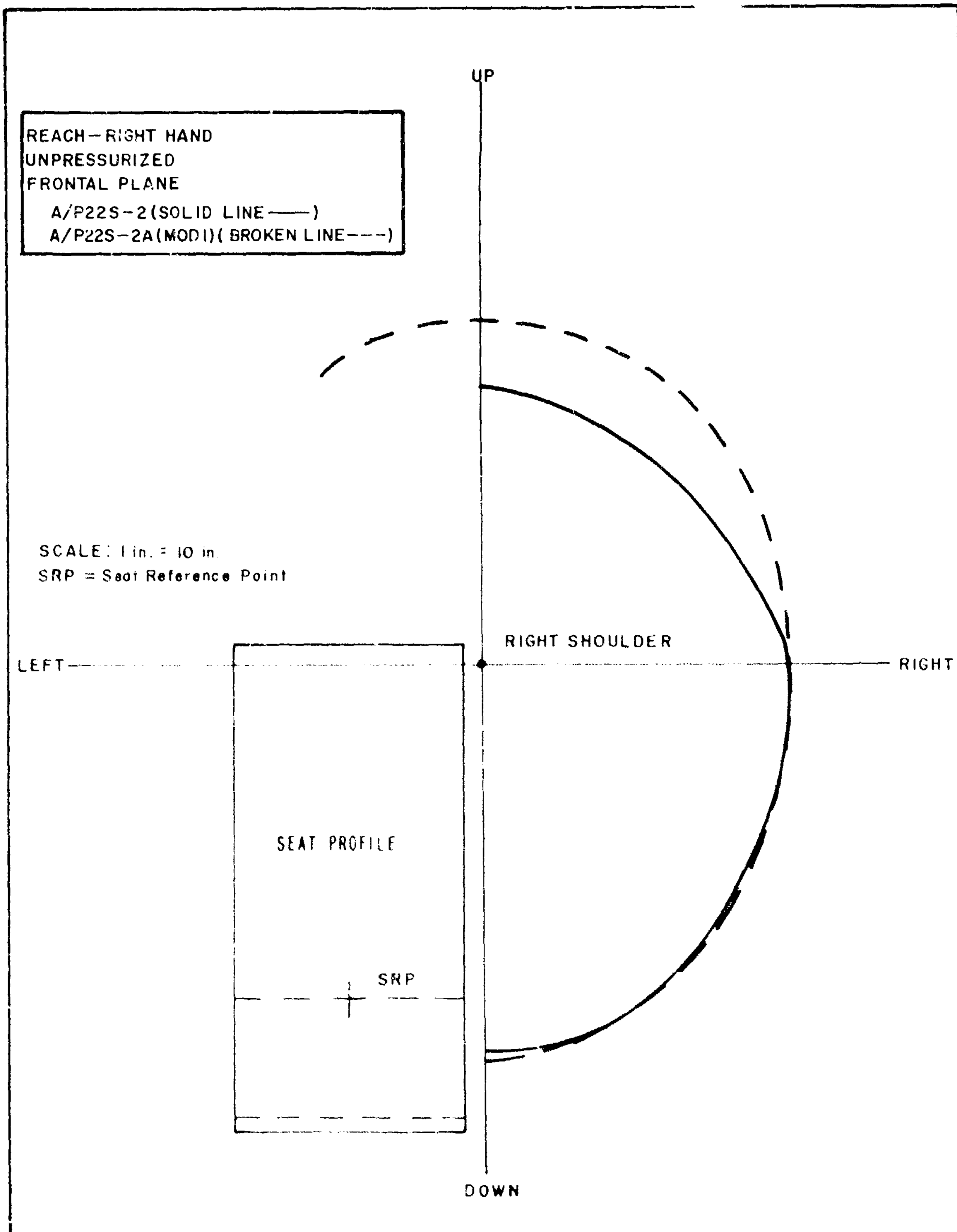


Figure 48. Reach Capability Contours

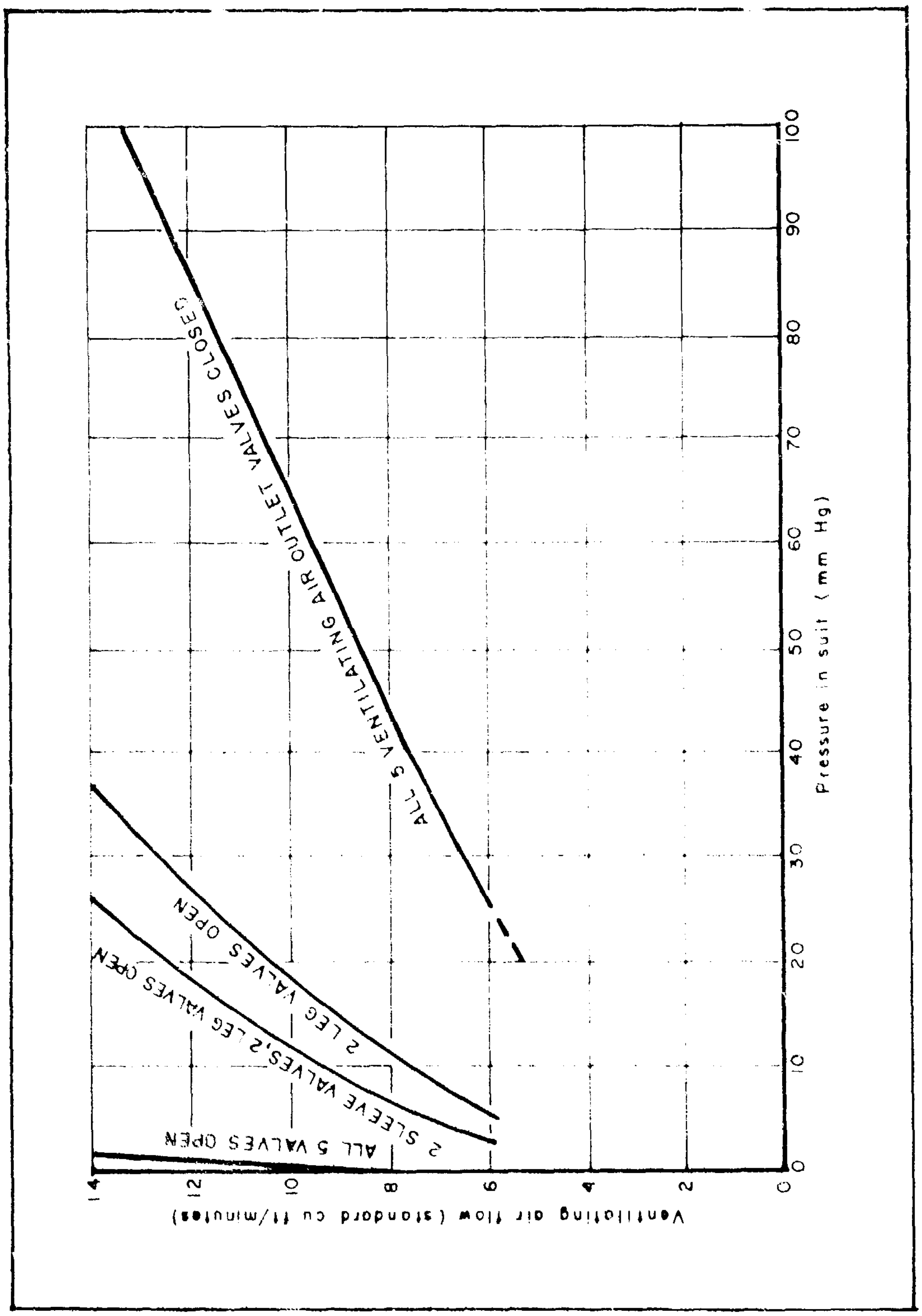


Figure 49. Pressure in the A/P22S-2A (Mod 1) Outfit Versus Ventilating Air Flow With Various Ventilating Air Outlet Valve Settings

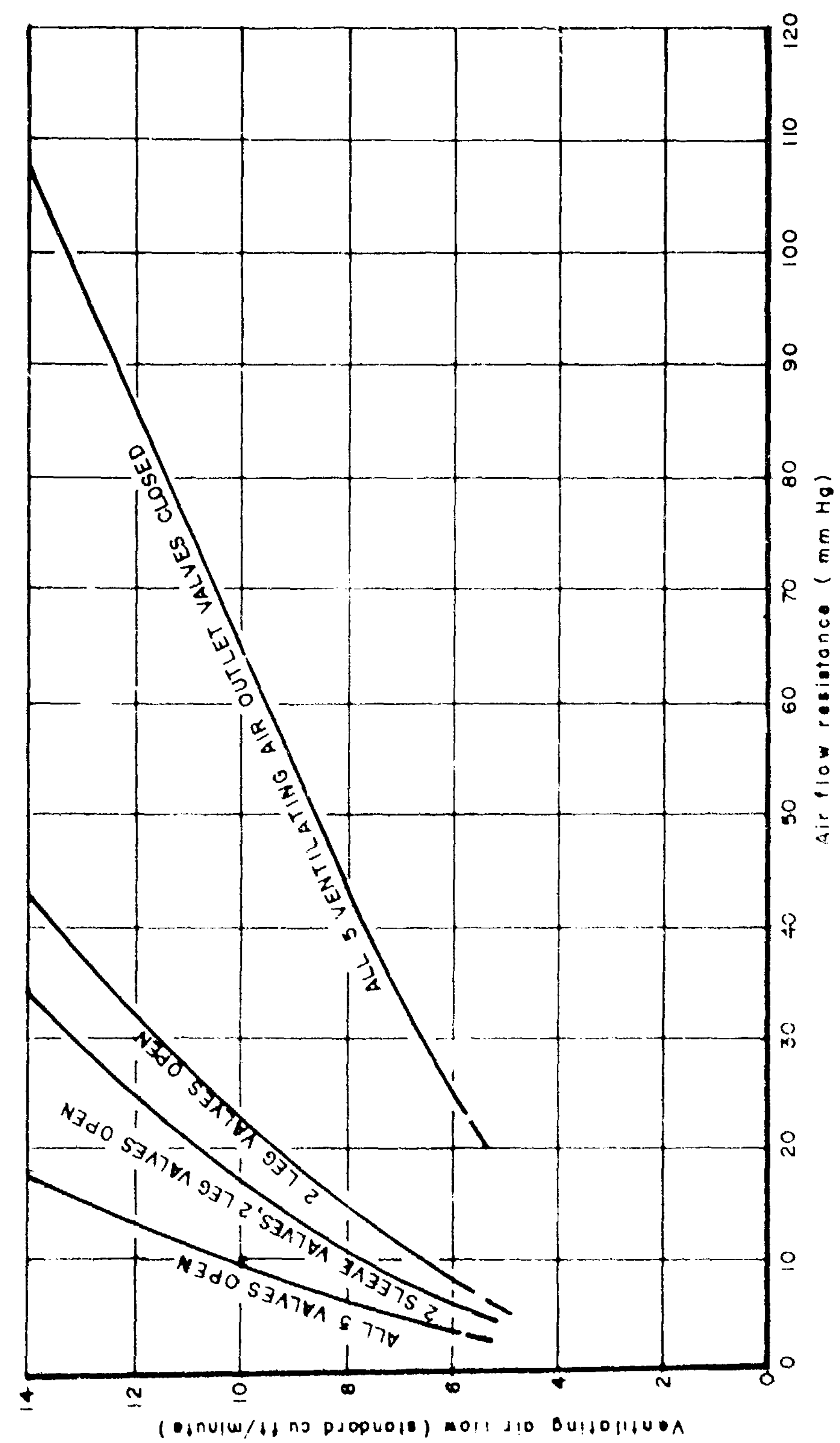


Figure 50. Air Flow Resistance Versus Ventilating Air Flow With Various Ventilating Air Outlet Valve Settings for the A/P22S-2A (Mod 1) Outfit

Figure 51. Suited Subject (Except Gloves) Shown at Baseline Rest Condition Prior to Entering Heat Chamber for Ventilation Efficiency Evaluation

Figure 52. Suited Subject Prior to Entering Heat Chamber for Ventilation Efficiency Evaluation

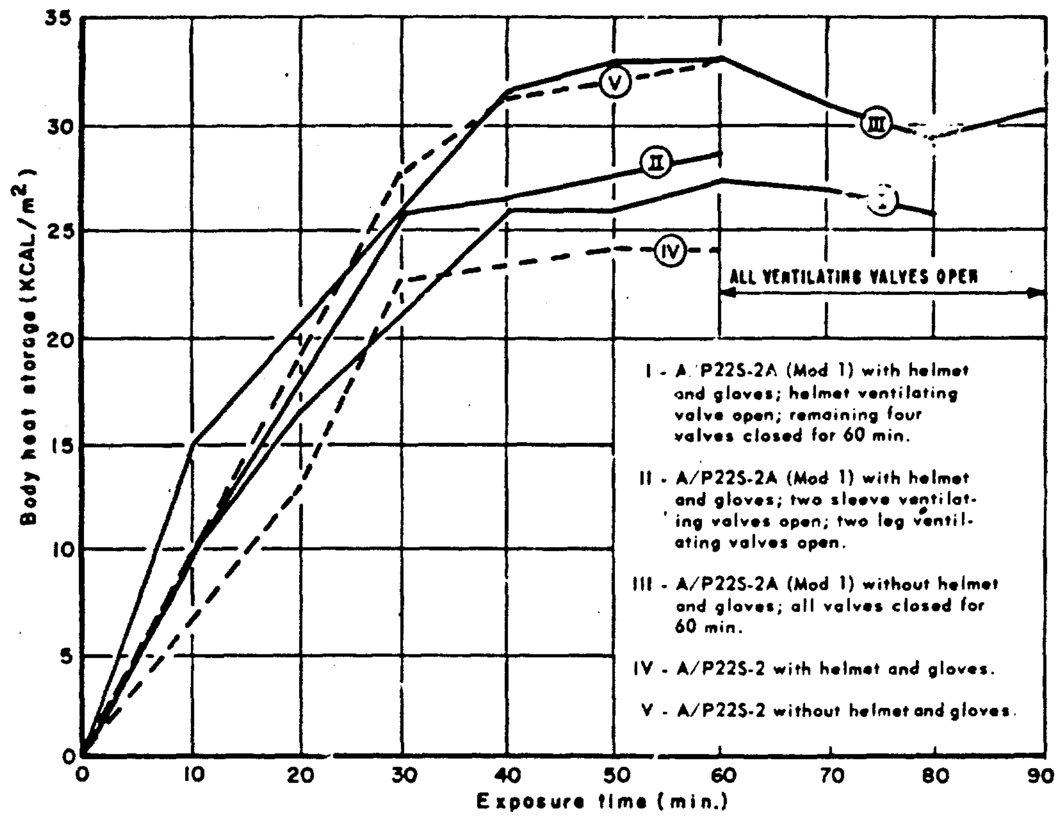


Figure 53. Body Heat Storage Versus Exposure Time With Both Outfits

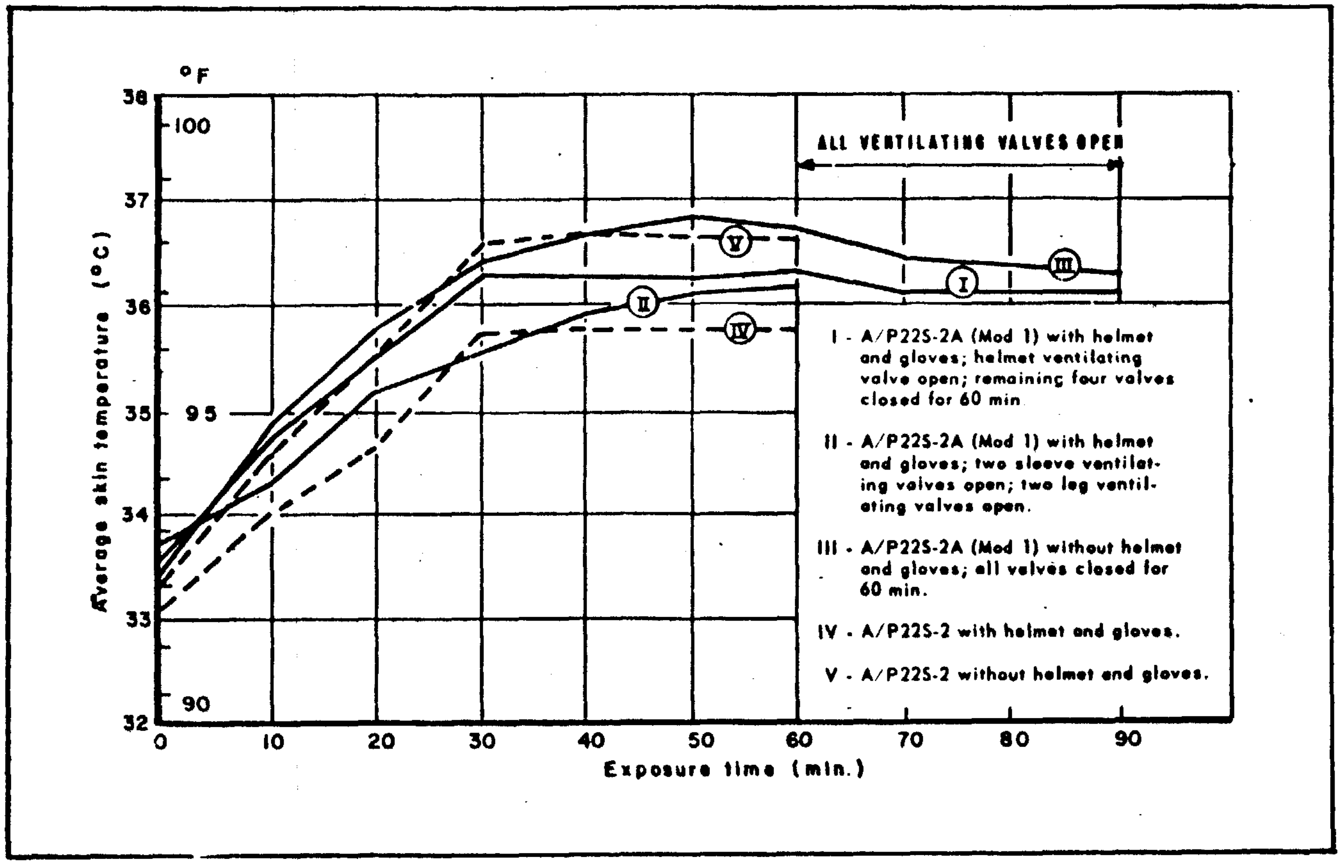


Figure 54. Average Skin Temperature Versus Exposure Time With Both Outfits

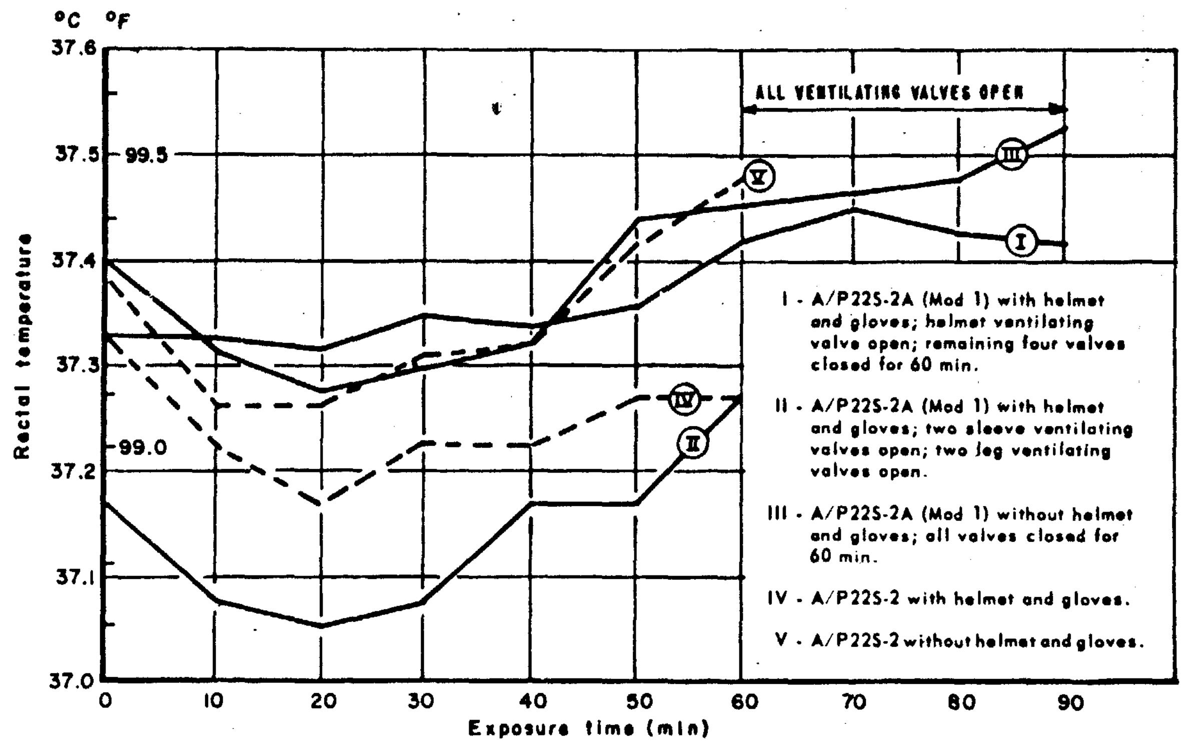


Figure 55. Rectal Temperature Versus Exposure Time With Both Outfits

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Gillespie, Kent W. Comparative Evaluation of USAF Standard A/P22S-2 and Improved A/P22S-2A High Altitude, Full Pressure Flying Outfit, SEG-TR-65-9. Systems Engineering Group, Wright-Patterson Air Force Base, Ohio. April 1965.

Kennedy, K. W. Reach Capability of the USAF Population. AMRL-TDR-64-59. Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. September 1964.

Tactical Air Command. Operational Test and Evaluation, High Altitude Personal Protective Equipment. TAC-TR-63-31A. November 1963.

Walk, Dieter E. Finger Dexterity of the Pressure Suited Subject. AMRL-TDR-64-41. Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio. May 1964.

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13. ABSTRACT

In this supplement, the A/P22S-2A (Mod 1) outfit is compared with the A/P22S-2 outfit. The components and factors compared include: Weight, leak rate and pressure relief, reach capability, work space, ventilation efficiency, and back pressure. The comments of the persons wearing the outfit were also considered. Results indicate that the A/P22S-2A (Mod 1) shows some improvement over the A/P22S-2; however further improvements are required to make the outfit more operationally acceptable. Specific recommendations are made as to those areas that need improvements.

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
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High Altitude Personal Equipment						
Personnel Protective Equipment						

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